Energy, Mines and
Resources Canada

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Ressources Canada

CANMET

Canada Centre for
Mineral and Energy
Technology

Centre canadien de la
technologie des
minéraux et de l'énergie

MINING RESEARCH LABORATORIES

ANNUAL REPORT

1987-1988

Compiled and edited by
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Canada

FOREWORD

After each fiscal year, the line Divisions of CANMET prepare Annual Reports for the period just ended. These reports, as complete summaries of the accomplishments during the period, are valuable documents. Distribution, within both the public and private sectors, is quite broad.

This report, written by several of the staff members of the Mining Research Laboratories, is an accounting of the achievements made during the 1987-1988 fiscal year. The document contains: listings of the many publications produced during the period; of the research contracts in place; and of our staff and their participation in committees and working groups. The compilation of the report, and its arrangement and visual impact, have been the responsibility of Donna Hill, MRL's Special Projects Officer.

The year 1987-1988 was a period of both excitement and challenge for MRL. Exciting, because of the diversity of research work underway in several of the provinces and also because of the much more effective communications with the industry and our various partners in research. Challenging, because ever-increasing demands for research and technical assistance have strained our resources to the limit. MRL's staff are to be congratulated for the dedication which has caused them to perform, on many occasions, above and beyond the normal call of duty.

During the year, a new state-of-the-art servo-controlled testing machine was commissioned in the Canadian Mine Technology Laboratory, at Bells Corners. This machine is among the most advanced now in service anywhere in the world and makes it possible for our scientists, and others, to perform tests under expanded ranges of both temperature and pressure. It is a unique national facility.

Also in 1987-1988, arrangements were completed with Laurentian University, in Sudbury, for the opening of a small MRL unit on their campus. Dedicated to mine backfill studies, the Sudbury Laboratory, will provide technical support for the work being done through the Canada/Ontario Mineral Development Agreement (COMDA).

The Mineral Development Agreements have been responsible for MRL becoming involved, with industry, in field-scale projects in Manitoba, New Brunswick, Ontario, and Saskatchewan. As a result, the orientation of the Division has been changed and relationships with its "stakeholders" improved greatly.

In comparing this report with its predecessors, the changes that have taken place are very apparent. We approach the future with a real sense of mission and of excitement for the challenges which lie ahead.

John E. Udd

John E. Udd
Director
Mining Research Laboratories

AVANT-PROPOS

Au terme de chaque année financière, les divisions des laboratoires de CANMET préparent un rapport annuel couvrant la période écoulée. Ces rapports qui présentent les grandes lignes des activités réalisées au cours de l'année constituent des documents précieux qui sont diffusés sur une grande échelle dans les secteurs public et privé.

Le présent rapport a été rédigé par des employés des Laboratoires de recherche minière. Il donne un aperçu des réalisations de l'année financière 1987-1988 et comprend des listes des publications rédigées pendant cette période, des contrats attribués pour la recherche, des noms des membres de l'effectif et de ceux qui font partie des comités et des groupes de travail. Donna Hill, agente des projets spéciaux était responsable de la compilation, de la mise en forme et de la présentation du rapport.

L'année financière 1987-1988 s'est révélée pleine de défis et d'intérêt pour LRM. Intéressante, en raison de la diversité des travaux de recherche en cours dans plusieurs provinces et également de l'amélioration marquée des communications avec l'industrie et les différents groupes qui collaborent aux recherches. Remplie de défis, car l'augmentation incessante des demandes d'aide technique et de soutien à la recherche ont presque épuisé nos ressources. Le personnel de LRM mérite des félicitations sincères pour son esprit de dévouement qui l'a incité à remplir des tâches excédant souvent les exigences de l'emploi.

C'est dans cette période également qu'une nouvelle machine d'essai servorégulatrice a été mise au point au Laboratoire canadien de technologie minière à Bells Corners. Cette machine qui est l'une des plus modernes au monde permet aux techniciens et scientifiques canadiens de mener des essais à des intervalles de température et de pression beaucoup plus variés. Cette installation est la seule du genre au Canada.

Des dispositions ont également été prises avec l'Université Laurentienne de Sudbury, pendant l'année financière 1987-1988, en vue de créer une petite unité LRM sur le campus. Le laboratoire de Sudbury qui sera voué à l'étude du remblayage des mines, fournira un soutien technique aux chercheurs qui travaillent à des projets mis sur pied dans le cadre de l'entente Canada-Ontario sur le développement minéral (EDMCO).

LRM s'est intéressé, avec l'industrie, à la réalisation de projets sur le terrain au Manitoba, au Nouveau-Brunswick, en Ontario et en Saskatchewan, en raison des ententes sur le développement minéral. Les ententes ont modifié les orientations de la division et provoqué une amélioration remarquable des relations avec les parties intéressées.

Une comparaison du présent rapport aux rapports de divisions des années précédentes ne laisse aucun doute sur la transformation qui s'est opérée. C'est avec une vigueur et un enthousiasme renouvellés que nous ferons face aux nouveaux défis et préparerons l'avenir.

John E. Udd
Directeur
Laboratoires de recherche minière

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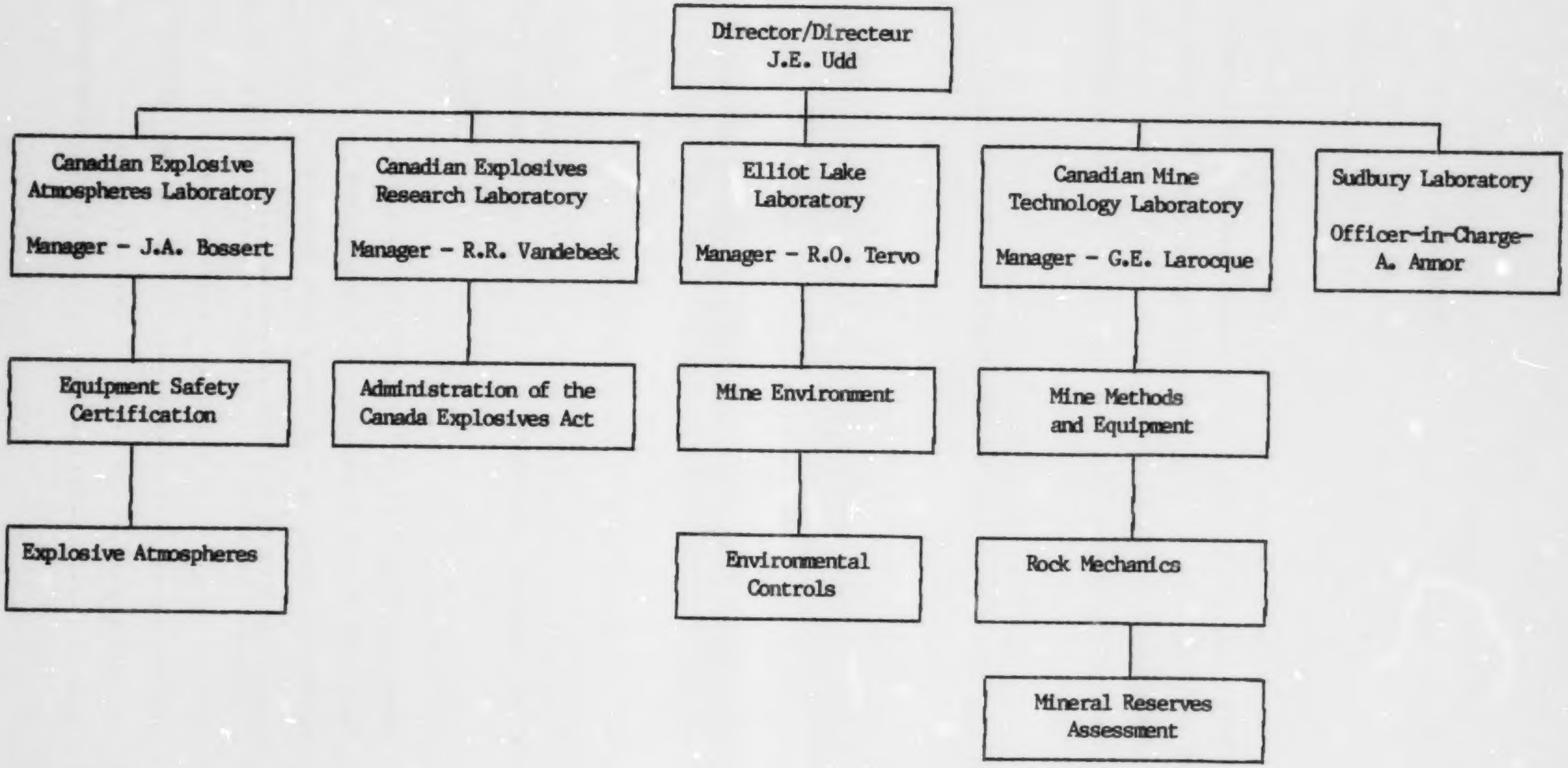
Mining Research Laboratories
Laboratoire de Recherche Minière


Director/Directeur
J.E. Udd
Canadian Explosive Atmospheres Laboratory
Manager - J.A. Bossert
Canadian Explosives Research Laboratory
Manager - R.R. Vandebeek
Elliot Lake Laboratory
Manager - R.O. Tervo
Canadian Mine Technology Laboratory
Manager - G.E. Larocque
Sudbury Laboratory
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Equipment Safety Certification
Administration of the Canada Explosives Act
Mine Environment
Mine Methods and Equipment
Explosive Atmospheres
Environmental Controls
Rock Mechanics
Mineral Reserves Assessment

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ADMINISTRATION

MINING RESEARCH LABORATORIES
1987
Reports Listing for Administration

MRL PUBLICATIONS

87-01(OPJ)	Rockburst research in Canada - 1987	J. Udd D. Hedley
87-20(TR)E	MRL Annual Report	D. Hill
87-20(TR)F	Rapport Annuel LRM	D. Hill
87-24(TR)	The microseismic monitoring system at the Camborne School of Mines, geothermal energy project, Rosemanowes Quarry, Cornwall, U.K.	J.E. Udd
87-34(OP)	Applied rock mechanics research at CANMET - Projects in progress through Fed/Prov MDA agreements	J.E. Udd
87-53(OP)	Summary reports of progress on tripartite USBM/MOL/CANMET research projects 86/87	J.E. Udd E.D. Dainty L. Geller
87-56(TR)E	Mining Research Projects (except for coal) 1987-88	D.M. Hill
87-56(TR)F	Projets de recherche minière (autres que sur le charbon) 1987-88	D.M. Hill
87-57(OP)	La recherche minière à CANMET: Impact des ententes fédérales-provinciales	J. Udd N. Billette A. Boyer
87-87(TR)	An overview of developments in rock mechanics in Canada 1983-1987	J.E. Udd
87-114(J)	La recherche minière à CANMET: Impact des Ententes Fédérales-Provinciales	J. Udd A. Boyer N. Billette
87-115(OP)	Small mines: The importance to Canada's mining industry, the characteristics, the problems, and the needs for technology	J.E. Udd N. Billette R.W.D. Clarke
87-131(OP)E	Applied research projects in progress at the Mining Research Laboratories of CANMET	J.E. Udd

87-131(OP)F	Recherche appliquée - Projets en cours aux laboratoires de recherche minière du CANMET	J.E. Udd
87-132(OP)E	The work of the Mining Research Laboratories Division of CANMET	J.E. Udd
87-132(OP)F	Les travaux de la division des laboratoires de recherche minière du CANMET	J.E. Udd
87-190(OPJ)	Les petites mines souterraines vues de l'extérieur; politiques et contribution de CANMET	J.E. Udd N. Billette

PART I

ADMINISTRATION OF THE CANADA EXPLOSIVES ACT

CANADIAN EXPLOSIVES RESEARCH LABORATORY

Highlights

During 1987/88, the Canadian Explosives Research Laboratory (CERL) examined 400 explosives for authorization under the Canada Explosives Act. Draft standards for several types of fireworks are currently being sent to industry for comment. Three explosives were analyzed and identified as having been used in attempted bombings. A comprehensive study (funded by industry) has provided information on the firing characteristics of high altitude display shells. A paper on the results has been accepted for presentation at the thirteenth International Pyrotechnics Seminar.

CERTIFICATION AND TECHNICAL ADVICE

Objectives

The objectives of this project are: to confirm the safety characteristics of all submitted explosives for authorization under the Canada Explosives Act; to provide technical advice on the manufacture, storage and transportation of explosives; and to investigate accidents.

Background

The Certification and Technical Advice project of the Explosives sub-activity has been developed to fulfill the requirement of "chemist" specified in Section 14 of the Canada Explosives Act. Since the promulgation of the Explosives Act in 1919, the capability has existed to certify explosives, to advise on technical problems of explosives and to investigate accidents. This capability has been developed continuously through contacts with manufacturers' laboratories, contracted research projects, in-house development projects and international contacts. Responsibilities under the project continue to increase because of technical advances in formulation and manufacture, increased concerns about the safety of transportation and storage of high hazard fireworks and propellants, and added international responsibilities.

Achievements

During the year, 400 new explosives were examined for authorization. These involved some 2261 sample units of work. Corresponding figures for the years 1986-87 were 445 and 1832, respectively, and for 1985/86 were 351 and 2528. Details of the samples by Classes are to be found in the "Summary of Samples Examined" section of this report. There has been a slight shift with the number of Class 7.2.1 samples examined being halved from the previous year and the number of Class 7.2.2 samples doubling.

There were no major accidents in explosives manufacture during the past year which required the laboratory's involvement. CERL did assist C-I-L in determining the cause of an accident involving inflatable airbag propellant. Recently a large fireworks magazine was destroyed by fire. Tests are currently being planned to determine the cause.

The laboratory responded to four requests to identify explosives involved in various bombing attempts. Three were successfuly identified. One of these was a rather unique product which had been manufactured by a U.S. manufacturer for the southern U.S. market.

The laboratory continued its work on those factors that cause explosions with ammonium nitrate. Work was completed on the reactions of ammonium nitrate with various metals and a report issued (ACEA/MRL 87-35(TR)). Some additional work was done on stearate coated ammonium nitrate to determine if the stearate had a sensitizing effect on the thermal decomposition. At the levels being used, no effect was observed.

ADMINISTRATION OF THE CANADA EXPLOSIVES ACT

Don Cox, Technologist/CERL, prepares to test an explosive using a Ballistics Mortar machine

For hostage takings and certain other situations, explosives forced entry charges have been developed consisting of a variety of explosive and non-explosive components. The laboratory was asked to evaluate what appeared to be reactions between some of these components that could affect the performance of these charges. The evaluation has been completed and a report drafted.

The transport container, developed by CERL, for forensic explosive samples has been accepted by the RCMP. Twelve units have been ordered to date. CERL, through OTT, is seeking to licence the manufacture of these containers on a commercial basis. A report is being drafted.

CERL has developed an explosive system that will remove the cones from a 3" tricone bit but leaves the remainder of the bit essentially intact. As a result, the flush hole of the drill string can be used to lower a Geological Survey of Canada developed instrument tube to the bottom of boreholes up to 400 feet in depth to measure ground water pressure.The use of this system will alleviate the need to pull the drill string and remove the bit. It is probable that the total system will be patented and an exploration company licenced to use it. A report is in draft form.

The laboratory has completed a large scale fire test on a Schedule IV container and its contents of 1200 electric detonators (ACEA/MRL 87-72(TR)). These containers are used to transport detonators safely on trucks carrying other explosives. It was found that the first detonators functioned after 25 minutes with all the detonators being consumed in the next 15 minutes. No massive explosion was encountered. Some additional work on non-electric detonators is scheduled for 1988-89.

A commercial blasting cap container was evaluated to determine its effectiveness for the purpose intended. A report was issued detailing the test results and recommendations made. Some work was done for the RCMP to determine the response of window/frame combinations to shock loading.

A comprehensive study (funded by industry) has been completed on the firing characteristics of high hazard display fireworks. A paper is being prepared which has been accepted for presentation at the Thirteenth International Pyrotechnics Seminar.

A contract was awarded to develop revised quality-distance storage tables for propellants. Recent developments in the manufacture of high energy propellants has raised concerns about whether the existing tables are adequate for these types of propellants. The contract is scheduled for completion in May, 1988.

Draft standards for some types of fireworks are being sent to industry for their comments. It is hoped that these will be finalized during the next fiscal year. Canadian recommendations have been accepted by the OECD-IGUS to develop international standards for fireworks. These should result in improved quality, improved safety in transport and use and facilitate trade.

ADMINISTRATION OF THE CANADA EXPLOSIVES ACT

Terry Craig, Technologist/CERL, loads a 0.50 caliber gun for projectile impact testing

EXPLOSIVES R&D

Objectives

Explosives R&D's main goal is to advance the technology related to the manufacture, storage, transportation and use of explosives.

Background

Explosives R&D at CANMET is primarily directed at furthering our technical capability to reduce safety and health risks involved in working with explosives.

CANMET efforts over the past few years have been directed to the development of mathematical models to predict explosives properties and detonation parameters in order to avoid the need for extensive field testing of explosives to determine, for example, the levels of toxic fumes produced on detonation. A new fume testing facility is under construction to measure experimentally toxic fumes. Studies are underway to develop a mathematical model to predict the consequences of a vehicle transporting explosives being involved in a collision (low velocity impact). The effects of temperature and fire on explosives during manufacture, storage and transport are being investigated.

Methods to determine properties of explosives are continually being developed or improved as new types of explosives are marketed in order to contribute to risk analysis methodology. New types of explosives are studied in depth to fully characterize them. An additional thrust will be the study of the properties of explosives, including detonators, in relation to their use in mining and civil engineering projects. These properties will include propagation sensitivity and time delay of detonators.

In cooperation with other countries through the United Nations, a unified international classification system is being developed to classify explosives for transport purposes. The Canada Explosives Act will shortly be changed to incorporate this new system.

Achievements

During 1987/88, CERL continued its long term study into the thermal stability of explosives. In particular, emphasis was placed on the use of differential scanning calorimetry and thermogravimetric analysis to compliment the laboratory's accelerating rate calorimeter. These three instruments are being used to evaluate the effectiveness of phase change modifiers for ammonium nitrate. The physical form of ammonium nitrate is affected by being temperature cycled through the phase change which can result in increased shock sensitivity.

Progress is also being made on the thermal decomposition kinetics of energetic materials. This problem is being tackled from two fronts; namely, theoretical modelling and experimental predictions. Theoretical calculations have been done on the critical thermal explosion parameter for the case of symmetrical heating. In addition a paper on the theoretical calculation of thermal decomposition of explosives from hot spot initiation was presented at the Combustion Institute (Canadian Section) 1987 Spring Technical Meeting. Detailed experimental studies into the thermal decomposition of nitroguanidine have identified that very low activation energies are determined during the onset phase of the decomposition. A paper on the topic (ACEA/MRL 87-77(OP)) was presented at the 42nd Annual Calorimetry Conference. A follow-up to this report (ACEA/MRL 87-76(J)) has been accepted for publication by Thermochimica Acta.

An analytical expression for the second virial coefficient of a gas which conforms to the n - m potential function has been developed. Comparison of this function with experimental second virial coefficient data allows the determination of intermolecular parameters. A paper (ACEA/MRL 87-130(OP)) on this topic was presented at the American Chemical Society 1987 Fall Meeting. After the completion of additional work, a revised paper will be submitted to the Journal of Physical Chemistry for publication. In various trial applications it has been found that the detonation fumes predicted for an explosive using this approach can be significantly affected.

The contract research on the development of a theoretical model for predicting low velocity impact initiation of bubble sensitized slurry explosives has been completed. The contract report is currently being reviewed for acceptance. It is planned to present a paper based on this research at the U.S. Department of Defence Explosives Safety Seminar this summer.

The detonation parameters and gaseous products of several commercial explosives were calculated by Tiger Code for evaluating fumes. Some modifications to the Code were required to meet the needs of these non-ideal explosives systems.

SUMMARY OF SAMPLES EXAMINED AT CERL
Calendar Year 1987

	No of Samples	Estimated Sample Units of Work
High explosives - Classes 1, 2 and 3	52	1040
Ammunition - Class 6.1	19	152
- Classes 6.2 and 6.3	6	48
Pyrotechnic mixes - Class 7.1	5	100
Fireworks - Class 7.2.1	137	137
- Classes 7.2.2 to 7.2.5	171	684
Miscellaneous	10	100
TOTAL	400	2261

ADMINISTRATION OF THE CANADA EXPLOSIVES ACT

Projectile, gun powder and cartridge used for projectile impact test

MINING RESEARCH LABORATORIES
1987
Reports Listing for CERL

MRL PUBLICATIONS

87-35(TR)	Studies into the thermal stability and reactivity of ammonium mitrate Part 3: Characterization of ammonium nitrate and metal reaction products	P. Lee R. Snippe R. Vandebeek
87-59(TR)	The removal of cones from tri-cone drill bits using explosives	D.L. Cox D.L. Wilson
87-72(TR)	Burning trial on schedule IV container	E. Contestabile R. Vandebeek R. Augsten
87-76(J)	Kinetic studies of the thermal decomposition of nitroguanidine using accelerated rate calorimetry	P. Lee M. Back
87-77(OP)	A study into the thermal decomposition kinetics of nitroguanidine using accelerated rate calorimetry	P. Lee M. Back
87-130(OP)	Fundamental information for TIGER Code calculations (2): Determination of potential energy function parameters	D. Jones R. Triebe

PART II

CANADIAN MINE TECHNOLOGY LABORATORY

MINING METHODS AND EQUIPMENT

Highlights

Phase I of the Denison Potacan Salt Backfill Study is now complete. The strengthening properties of salt indicated in modelling studies using established salt fill properties has been, and is continuing to be, confirmed in a large instrumented test stope study. Following model recalibration based on the stope study results, mine layout will be undertaken using backfill in future mine development. This constitutes Phase II of the project.

Through visits to British Columbia, Manitoba, and Quebec, the coverage in the 1987 Index of Mining Technology Projects was expanded. As well, the Index was completed, as planned, by the earlier date of August 1987. It is anticipated that this completion date can be maintained for future editions.

A users manual has been developed to aid industry use of the computer programs VCRM, LDBB and PGRAP. These computer programs were developed by Mining Resources Ltd., for CANMET under contract, for use in underground blast design, vertical crater retreat, and large diameter bench blast methods. A package consisting of the program disk and user's manual will be made available to interested users on a cost-recovery basis.

Objectives

On a continuing basis, MRL develops and evaluates mineability and mine operational economic criteria for hard rock mining in Canada, and prepares, annually, estimates of planned and projected production capabilities of uranium mines.

Background

Technical and economic evaluation of existing and potential uranium mining operations is an essential component of uranium reserve and resource assessment, which has been assigned to CANMET on behalf of EMR's Energy Policy Sector. In addition, reliable estimates of uranium production capabilities for individual properties, plus projections of future production, are also required for the EMR Uranium Resource Appraisal Group (URAG). Resulting information on Canadian uranium reserves, resources, and production is also required as input to policy decisions on domestic and export sales quotas for each projected and operating unit in Canada, as well as for the granting of production licences by AECB.

To meet the above commitment it is essential for CANMET to acquire realistic production cost data, to develop adequate mine operations evaluation procedures and to establish a base of unit productivity related to existing and developing mining technologies. Computer techniques will be used where feasible.

The development of such data bases and expertise, fortunately, is generally applicable to all hard rock mining operations. This results in a general mine evaluation capability in MRL/CANMET which will be of value to government policy organizations, as well as to the Canadian mining industry.

Achievements

As part of the annual exercise for estimation of reasonably assured reserves, cut-off-grades for all of the uranium deposits in Canada were estimated based on three levels of uranium market prices. Visits were made to operating uranium mines and to company offices to gather information on their present activities and future plans. Estimates were also made of present and future uranium production capabilities. All of the information was presented as an internal report for departmental use.

A final draft of a user's manual for the implementation of a ventilation network program, for use with a PC computer, has been completed. This program has been successfully used in hard rock mines in Canada.

A large number of engineering studies, reviews and investigations have been carried out in order to respond to departmental and non-departmental requests for funding, and for information on various aspects of mining technology.

ADVANCED MINE EQUIPMENT TECHNOLOGY

Objectives

Studies are carried out, by MRL: to assess the potential productive impact of worldwide developments in new mining equipment and other pertinent advanced technologies, e.g., automation and robotics; to characterize the dust produced by major sources in hardrock mines and to assess dust control measures; and to demonstrate the capabilities of environmental monitoring systems. On a continuing basis, MRL conducts reviews of mine equipment and prepares state-of-the-art reports. It promotes the development and demonstration of new mine equipment/equipment systems for use in all parts of the mining cycle.

Background

The Canadian mining industry is facing its toughest competition from third world countries. To remain competitive in international markets, it has to find the ways and means of improving productivity, while meeting higher safety and environmental standards.

The successful applications in terms of productivity gains of microprocessors, sensors, data transmission, monitoring and control systems in various manufacturing and processing industries provides an incentive for their applications in underground hardrock mining. There exists considerable potential for the transfer of such technology in the areas of mine equipment automation, remote control of operations and optimization.

Achievements

A contract has been completed to evaluate a concept for a blasthole depth measurement test unit. The units function, using accoustic waves, would be to:

(1) Measure the depth of a blasthole, open, blind, or filled with water;

(2) Measure the height of the muck pile in a bulk mining stope to efficiently design blast sequences and to manage draw point mucking control.

The concept was field-tested in INCO's research mine in Sudbury. It indicated that an instrument can be developed to measure the depth of a blast hole. To measure the height of the muck pile, however, more research is required.

An extensive evaluation of various environmental sensors in a simulated mine environment has been completed and a report/paper written. The sensors used in this study were to detect: carbon monoxide, carbon dioxide, nitric oxide, nitrogen, sulphur dioxide, methane, air flow, absolute pressure, temperature, and relative humidity. This study is a significant contribution to the mining industry and lays the groundwork for other major projects for monitoring and control of air quality in mines.

A research scientist from MRL, in cooperation with Noranda Research scientists, established through field experimentation and data collection that CO_2 concentration can be used as a surrogate to estimate the levels of other diesel pollutants. This provides raised expectations that air quality control in dieselized mines can be automated based on a relatively simple measurement system. The work is continuing.

CANADIAN MINING TECHNOLOGY COORDINATION

Objectives

The objective is to promote cooperation and to improve efficiency in the Canadian mining industry by maintaining a national information bank on current and developing mining technology and by preparing state-of-the-art reports on mine operational problems.

Background

Some progressive mine operating companies are collaborating with consulting firms, equipment manufacturers, universities, government laboratories and research foundations to improve and develop state-of-the-art mining technology. Many companies are also involved in in-house research which is aimed at improving their own operations but which could be applied to others in Canada. Because their results are generally not published or made known to potential beneficiaries, the technological impact of their research is not felt across Canada. To dissipate the knowledge, MRL has undertaken to collect information on the research/projects/activities of these organizations, to compile them, and to distribute these to the mining industry. The "Index of Mining Technology Projects" is becoming well-known throughout the industry.

Achievements

The 1987 Index of Mining Technology Projects in Canada was produced on schedule. There were 683 organizations included this year - an increase of 32% over 1986. The number of projects listed also have increased considerably. It was evident from the study that projects related to ground control had predominance over any other, but there was an increase of 65% in projects related to hi-tech applications in mines. The Index was very well received by the industry. This year, to meet greatly increased demand, 1,400 copies were published.

MATERIALS HANDLING AND OPERATIONS RESEARCH

Objectives

New concepts for material handling systems, which provide improvement in productivity and safety, are being developed for use in underground and open pit mines. New ventilation models are being developed for the determination of heat transfer in different media.

Background

Since the start of the metals price depression in the early 1980's, the Canadian mining industry has realized the need to be a leader in world mining technology in order to maintain its competitive position. Besides deployment of reliable and proven equipment, increased use of mathematical modelling (OR) and computer systems to optimize mine equipment utilization is required, such as with open pit truck transportation or trolley-assisted haulage systems. Automation and robotization of open pit mine haulage trucks could result in a saving of $150,000 to $200,000 per unit.

The use of CAD/CAM systems in mine design could result in a considerable savings in professional and skilled labour costs. It would also assist the optimization of expensive mine development. Some of the advanced management systems already used in manufacturing and process industries could be advantageously used by the Canadian mining industry.

Achievements

A report on orebody modelling, geological contouring and ore reserve assessment was written. This is a part of an overall project on computer-aided mine design and planning. A model is being developed to establish blending requirements from mine face to mill. The model is being developed and tested using the ore blending characteristics of an open pit operation.

EVAPORITE MINING METHODS

Objectives

Contract research is being carried out in the areas of ground control, environmental controls, and productivity. The objective is to increase potash recovery over current levels in Canadian mines. Ground control research is being focussed on predicting mine opening behaviour and the effects of backfill on stability.

Background

Present studies are directed towards monitoring excavation behaviour by numerical modelling. Material properties determined in field and laboratory studies are used as input in these studies.

In 1985, ground control research with respect to potash mining expanded into New Brunswick as a part of the Canada/New Brunswick Mineral Development Agreement. This multi-year research program is directed at developing the technology/knowledge essential to use salt waste as a backfill material. If structural support provided by salt backfill proves effective, increased ore recovery can be expected.

Achievements

Results indicated that it takes more than 10 years to achieve closure between roof strata and the top of the backfill. Support in the vertical direction will be insignificant so long as the density of backfill is much less than that of the roof strata. It has been proven that backfill will reduce floor heave and wall convergence. A contract to verify numerical model predictions (Phase II), by field data, was signed on December 24, 1987.

A rock mechanics study was carried out at the International Minerals and Chemicals Company at Esterhazy, Saskatchewan, to identify parameters for numerical modelling. In this context, induced stresses and deformation rates were measured in two mining panels.

A contract, was completed at Central Canada Potash to apply the subsidence model SPASID to subsidence data obtained from potash mining operations. A technology transfer seminar was conducted on January 27 and 28, 1988 at the University of Saskatchewan in Saskatoon.

ROCK MECHANICS

Highlights

Even before the completion of the Dense Fill Technology projects now in process through the Canada/Ontario MDA, the Ontario mining industry wishes to take advantage of the new dense fill technology that has been developed. Dome Mines is planning to add two tail spinner units, which will be used with cement/flyash/unclassified tailings mixes developed and tested in the COMDA project. INCO is planning to proceed with a $6M dense fill plant for cement/slag/classified tailings emplacement, on the basis of COMDA study results. Falconbridge can foresee a $1M saving in capital equipment costs for pumping from new workings that they plan to develop at the 1800 level of an existing mine.

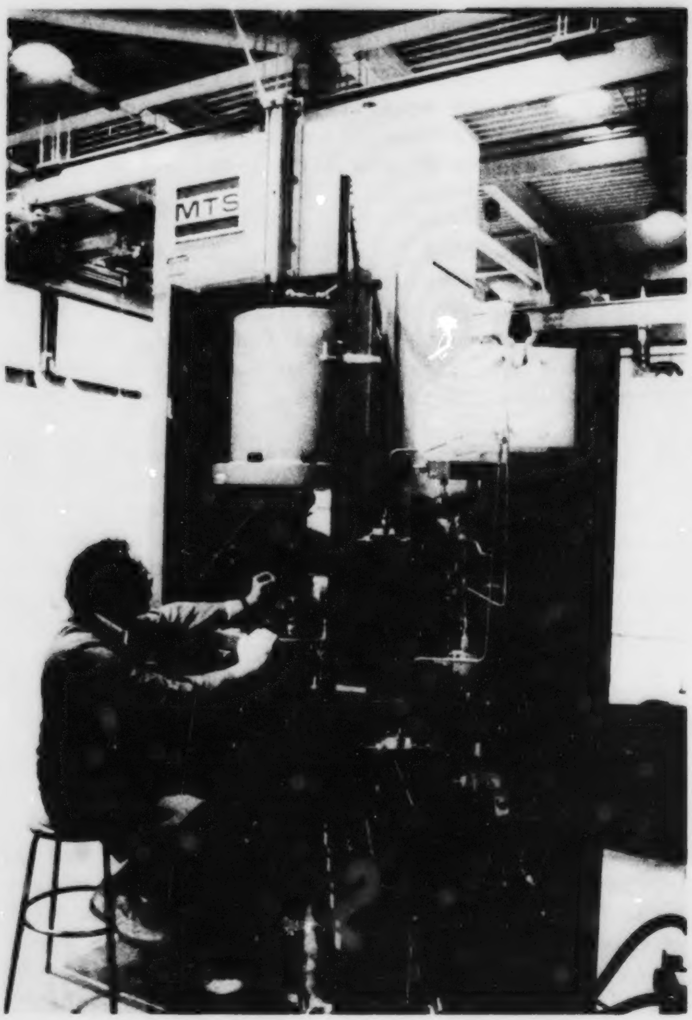
The Niobec Study is now drawing to a close. The study is a classic example of how technology transfer can be made to industry and of how industry can benefit from MRL-developed technolgy and expertise. The study provided mine planners with information on the possible impacts of mining and mining sequences, the various stope geometries and sizes, and the artifical support requirements.

The "MRL Strain Monitoring System" has provided excellent data on mine-induced stresses, in the elastic range, in the Niobec study. These have confirmed the anticipated stress transfers accompanying mining, and support the conclusions drawn as to the stabilities of the developed stopes. MRL strain cells are to be part of a field monitoring system at INCO's Creighton Mine. This trial is one element of a $1M contract being carried out by INCO under the Canada/Ontario Mineral Development Agreement.

Prelimary design guidelines for surface crown pillars and a lexicon of English/French terminolgy related to surface crown pillars have been issued as initial phases in the preparation of a surface crown pillar hand book.

Cooperative rock mechanics studies, similiar in scope and purpose to the Niobec study, have begun with Eldrich and Montauban Mines. The stability study of the Selbaie surface crown pillar with its highly altered rock is now complete. The latter study resulted in the development of new sampling, modelling and instrumentation technology for use in geotechnical investigations in highly altered rock formations.

ROCK MECHANICS



Bernie Gorski, Technologist/CMTL, installs a test specimen in the triaxial chamber of MTS test facility

ROCK MASS CHARACTERIZATION

Objectives

A handbook on surface crown pillars for safe and economic design, including guidelines for the design process, is being developed to meet the requirements of the mining industry. A number of research projects have begun to characterize basic behaviour in a variety of rock mass settings. Empirical, statistical, and deterministic models are being developed to predict stable structures.

Background

It is recognized that some specific structures in mining have special stability and support requirements. Surface crown pillars constitute a component of those mine structures which require special consideration.

Special attention is required to delineate the reasons for stability/instability of such structures and the best methods of retrieval of critical parameters, of failure mechanisms, evaluations of stability, and support requirements.

When properly included in a valid design approach, rock mass characterization provides the focus for dealing with surface crown pillars. Because of the uniqueness of these mine structures, in a material and comparative sense, such characterization must employ methods and equipment used in the fields of mining and civil engineering. These would benefit from the availability of a surface crown pillar-specific characterization system. Such a system would be applicable to large, multiple openings common in mining and would supply an understanding of how the rock mass interacts with support systems such as backfill.

Achievements

Special surface crown pillar cases are being studied (laminated rock, Niobec Mine, Quebec; blocky rock, Eldrich Mine, Québec; intensively weathered rock, Les Mines Selbaie, Québec) which, when combined with 24 completed case studies of Canadian surface crown pillars (located in Manitoba, Ontario, Québec and New Brunswick), will provide a cross section of various rock mass settings and characteristics.

Progress has been made towards developing a technology for rock mass characterization: namely, a computer-based logging system and the application of geotomography and wave attenuation to map discontinuities in three dimensions. Analysis of case study results were presented to the Quebec Metal Mining Association and the CIM. The development of new diamond drilling techniques in soil-like material was presented to the Canadian Geotechnical Society, and a strategy of recovering crown pillars was also presented to the QMMA. Research has begun on: failure mechanisms in highly schistose rock masses; development of hybrid numerical models (distant and boundary elements) support requirements in weak rock masses; plug-like failures in steep-dipping narrow vein deposits; and recovery of a surface crown pillar while predicting and controlling 40m of caving overburden.

ROCK PROPERTIES AND SUPPORT SYSTEMS

Objectives

Research investigations are carried out to establish the peak and residual strengths, deformational, and other rock properties required in ground control investigations. Laboratory test procedures and equipment are being developed constantly to specifically meet the requirements of such investigations.

Background

An increasing portion of Canadian underground mining in the future will take place under high stress. Under such conditions, the post-failure strength and deformational properties of the rock materials must be taken into consideration in design.

Ground support for deep mining conditions requires research. The effectiveness and limitations of present underground support systems need to be established. New methods of ground support must be developed.

The increased accuracy and sophistication of analytic methods related to mine design, requires that more exact constitutive equations concerning rock strength and deformational properties be developed. New test methods and procedures must be developed to permit laboratory determinations of the required properties.

Achievements

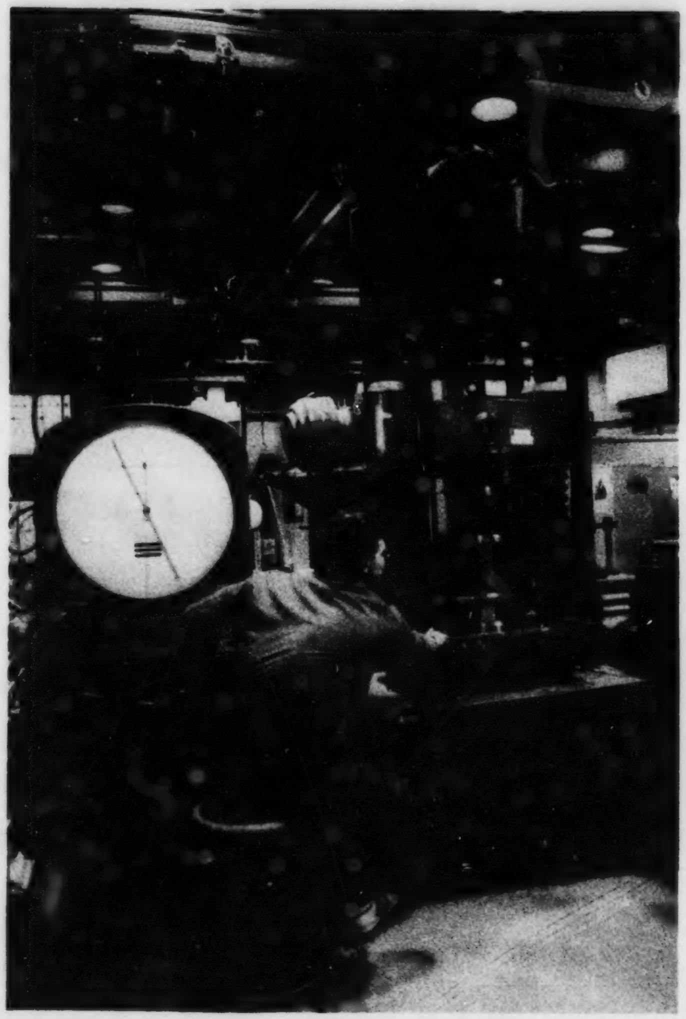
Material property investigative programs have been developed and used to meet the specific mine rock information requirements of ground control investigations being carried out at the Detour Lake, Central Canada Potash, Niobec, Lingan, and Prince Mines.

The installation of MRL's new servo-controlled rock testing system has been completed. Good progress is being made towards the development of the procedures which will be used to determine the peak and post-failure strength and deformational properties of mine rock.

Two test programs have been completed as part of the process of developing test procedures to establish the strength and deformation of rock joints under underground mine stress conditions. The size effect of joint roughness has been investigated by a drill shear method. Joint residual strength properties have been established using the MRL confined shear test methods. Test results for the two programs are presently being analyzed.

Based on a novel concept, the development of a support system design and evaluation method has been completed. With this method, design graphs can be used to determine effective and economic support systems in specific rock mass conditions.

ROCK MECHANICS



Rand Jackson, Physical Scientist/CMTL, carries out stiff test using Tinius Olsen 1.3MN test machines

NUMERICAL MODEL DEVELOPMENT

Objectives

Analytic numerical modelling studies are regularly carried out as part of applied ground control investigations. New numerical models and software packages are developed, or modified, with improved capabilities to simulate mine geometry, sequence, rock mass behaviour and artificial support behaviour. A particular effort is being made to develop analytic packages suitable for use by small mines.

Background

The prediction and evaluation of rock mass response to mining is becoming progressively more important in mine design and planning.

Information provided by such studies can be used by mine staff in the selection of mining methods, layouts, stope and pillar dimensions, and mining sequences. Ground control and support requirements are given greater consideration in present analyses.

Numerical models are finding increasing use in mining, in order to predict ground response to mining and to evaluate the effectiveness of support systems. With time, the models are becoming more sophisticated and better able to simulate actual mine conditions in terms of mine geometry, mine sequencing, and material properties. Further research leading to the development of improved models is required if mining is to fully benefit from this technology.

Achievements

The second phase of a cooperative research project with the Niobec Mine, and the Centre de Recherches Minérales, Québec, to determine ground behaviour/response to mining and to establish guidelines for ground control and mine planning, has been completed. Additional effort is continuing to study mine stability at the lower level of the Niobec Mine.

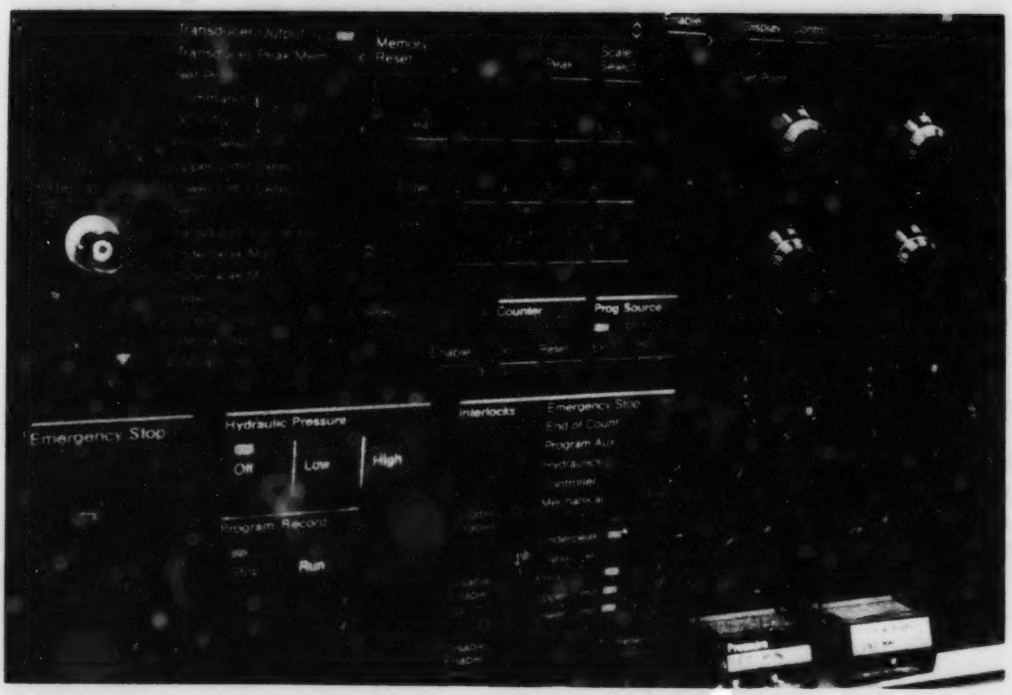
A number of large three-dimensional finite element models were constructed and analyzed, for the assessment of the stabilities of stopes and crown pillars in the upper level of the Niobec Mine.
A stability assessment of C-102-23 stope under a variety of loading conditions was made. In addition, a large 3D finite element model, which was used to examine the effect of stoping below the 450 level and the removal of the sill pillar between the 450-600 levels, was also completed.

Three reports (M&ET/MRL 86-97(TR), M&ET/MRL 86-145(TR), M&ET/MRL 87-96(TR)) were issued. A joint paper (MRL 87-14(OP,J)) with the Niobec mine staff was presented at the 28th U.S. Rock Mechanics Symposium, Tucson, Arizona, June 29 - July 1, 1987.

Cooperative research studies on mine stability assessments for the Montauban and Eldrich Mines have been initiated.

ROCK MECHANICS

Bernie Gorski, Technologist/CMTL, studies a print-out from the MTS Console System


Transducer Output
Memory Reset
Peak
Scale Select
Enable
Display
Set Point
Counter
Prog Source
Enable
Reset
Emergency Stop
Hydraulic Pressure
Off
Low
High
Interlocks
Emergency Stop
End of Count
Program Aux
Hydraulics
Controller
Mechanical
Program Record
Run

Close-up of Control Panel

The size of three-dimensional models which can be handled on the Departmental Cyber 840 computer, in terms of both computer capacity and costs, seems to be reaching a limit. A benchmark test on a Cray-1S computer, conducted in cooperation with CSC/EMR and Cray Canada Inc., indicated that the three dimensional finite element software (SAP3D), such as used in the Niobec study, can be run more cost effectively on a Cray 1S.

Efforts are continuing to upgrade MRL's VAX/VMS system and hardware capabilities for mining applications. The VAX/VMS system has been brought up to level 4.4. To improve graphic capability for mine design a 280 MB disk was installed for the Sun workstation. The Sun OS (operating system) was brought up to level 3.2, and the GKS graphic software package has been implemented.

UNDERGROUND NUCLEAR WASTE REPOSITORY

Objectives

The general objective is to develop field and laboratory investigational methods, equipment and procedures to assess rock formations for high level radioactive waste disposal in terms of their thermal, mechanical and ion transport properties, and to carry out related investigations on research area formations and at the planned underground research facility site. The studies carried out on research area formations and the underground research facility site will be used in pathway analysis studies related to concept assessment and in the design of the underground facility.

Background

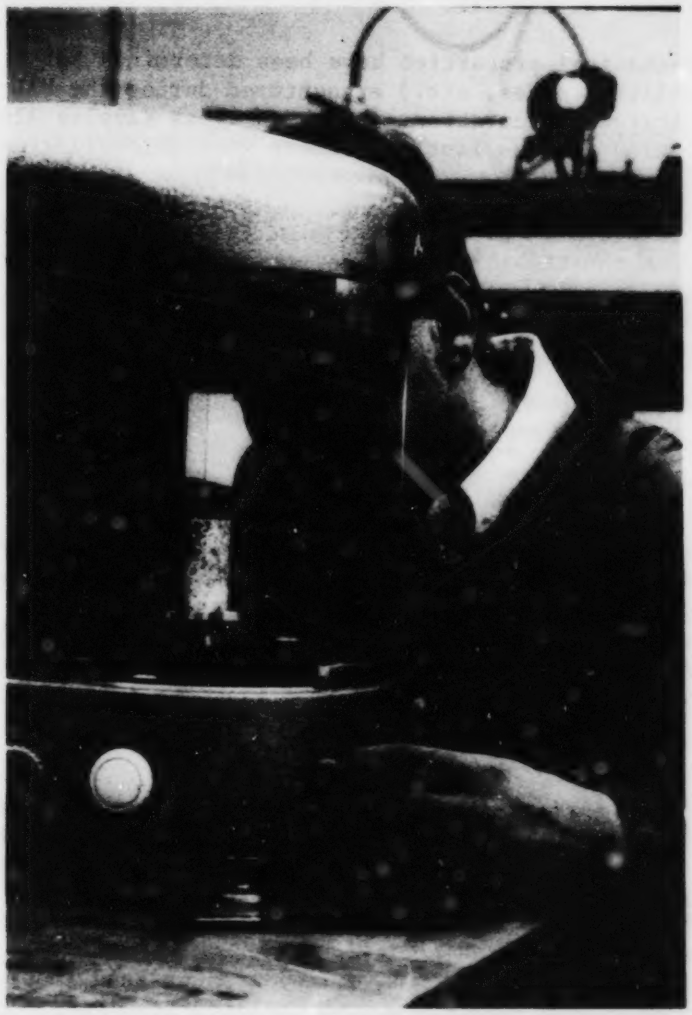
Disposal of spent fuel rods will become a critical aspect of nuclear electricity generation. This project is an integral part of a larger Atomic Energy of Canada Limited's (AECL) directed Canadian Nuclear Fuel Waste Management Program (NFWMP) to find safe and effective methods of disposing of high-level nuclear wastes.

MRL's present participation in the NFWMP has evolved over the past ten years from an initial request, in 1973, from AECL to EMR for geoscientific advice on possible disposal of high level wastes by burial and subsequent completion of a geoscience EMR sub-program on igneous formation site investigation.

Achievements

Evaluation of the Barton-Bandis Joint Model continued, with studies to investigate the effects of scale on rock joint shear strength. This has included index as well as direct shear testing on three sample sizes cut from the same large jointed specimen. The results of this work will

ROCK MECHANICS



Geoff Saunders, student from Waterloo, conducts the weighing of a rock specimen eventually assist in relating laboratory small-scale rock joint behaviour to in situ rock mass conditions.

Several suites of rock were tested in uniaxial compression to discover if any significant anisotropy exists in the strength and deformation properties of Lac du Bonnet granite specimens obtained during shaft sinking at the URL.

Uniaxial mechanical properties have been determined for 5 anomalous rock types (zenoliths, dykes, etc.) encountered during the URL shaft sinking and underground excavation. Tests on these samples also included determining compressional and shear wave velocities and their related dynamic properties.

High temperature/high pressure triaxial tests were conducted on core obtained from the URL site. Unlike previous test programs, samples were heated under pressure to determine if any significant effect on the thermomechanical rock properties could be observed.

INSTRUMENTATION DEVELOPMENT

Objectives

Investigations are carried out to identify the present and future requirements of the mining industry for geotechnical instrumentation. Research studies are then undertaken to design and develop instrumentation to meet some of the more pressing needs. Finally, field testing is carried out to determine that newly-developed instruments meet industry's requirements.

Background

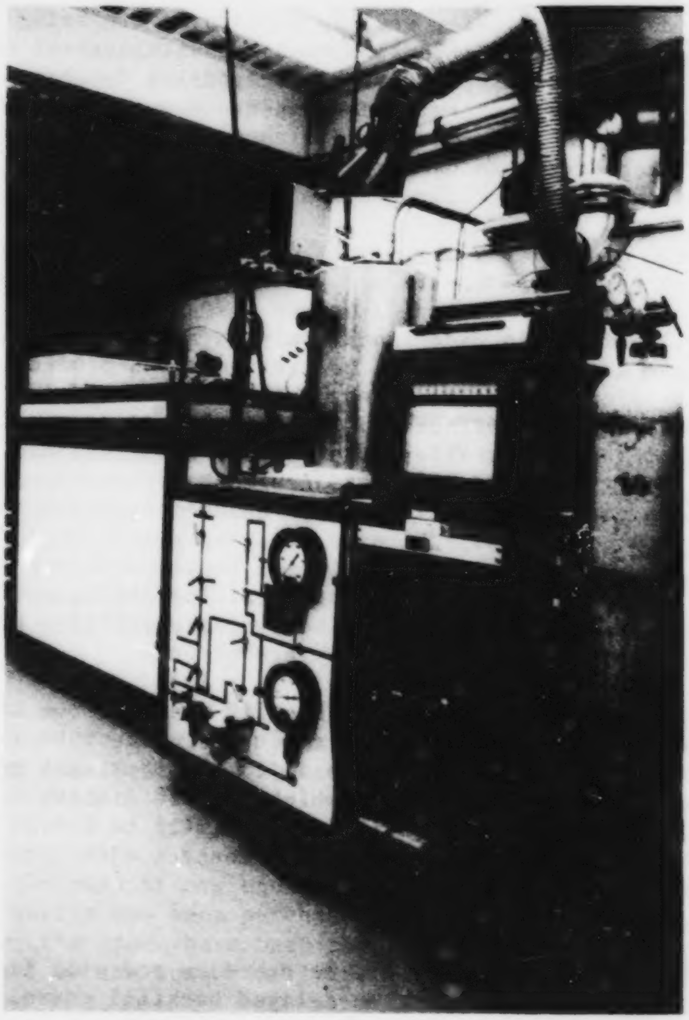
A wide variety of geotechnical instrumentation has been developed over the years for use in mines, but very little objective testing and field evaluation has been carried out. Because of MRL's access to mines and its expertise, MRL is in an excellent position to evaluate such instrumentation in terms of performance criteria and usefulness.

There is also a need to develop new instruments and instrument systems for use in ground control studies related to mining. MRL can participate very effectively in the development of such new geotechnical instrumentation for the mining industry. Priority is given to highly sensitive and reliable instrumentation to monitor borehole deformation in hard rocks with automatic data logging equipment.

Achievements

A new vibrating wire strain monitoring unit was developed. Six prototype units were used in the Niobec Mine to determine ground reaction during drift development. The results have been very encouraging and further installations have been made at the Creighton

ROCK MECHANICS



High pressure, high temperature transient permeability apparatus

Mine, Sudbury, and at the Denison Mine, Elliot Lake. A continuous data logging system is under development. During 1987-1988, arrangements were made to commercialize the MRL vibrating wire strain ring through ROCTEST of St-Lambert, Québec.

CANADA/MANITOBA MINERAL DEVELOPMENT AGREEMENT

Objectives

Design guidelines and safer scaling procedures are being developed for the Vertical Block Method (VBM) of mining. With respect to the design of deep under ground openings, a geotechnical database system and numerical analytic package is being developed. Ground stability evaluation criteria are being developed with particular reference to en echelon lensed orebodies. An underground mine communication system is to be installed and evaluated for general use in multi-level, hard rock metal mines.

Background

Cut-and-fill mining is used extensively in northern Manitoba. When used in poor ground conditions, however, serious production and safety hazard problems can be realized. With this method, miners must work directly under ground with caving potential. Because present cut-and-fill mining requires extensive scaling, heavy support, blast control and skilled labour, modified or new methods, such as VBM methods, are being investigated for their replacement potential.

Improved ground control also requires a better understanding of rock mass response to mining and the causes of instability. Therefore, studies in the area of rock mass behaviour, mine stability, numerical modelling and improved mining technology are planned.

Safety in underground mines would benefit greatly from the availability and use of more effective radio communications systems. Warning systems for fires, based on the injection of stench gas in mine air, are inadequate for working areas which receive limited ventilation. A reliable communications system will be installed and evaluated which will permit mine-wide voice contact with personnel.

Achievements

All of the research projects are on schedule and will finish in the 1988/89 fiscal year. One project, on delayed backfill consolidation, was cancelled at the request of the contractor because of their inability to complete the work. Changes to operating schedules meant that the proposed underground test site would not be available for several years, and no other available site was suitable. This research is still important to the contractor, to the mining industry, and to MRL.

The underground communication system has been installed and the voice communication side of the system is now working. The data communication side is being readied for testing. This project has generated a lot of interest since underground communication is one of the requirements for underground automation.

CANADA/ONTARIO MINERAL DEVELOPMENT AGREEMENT

Objective

Research is being carried out to improve the productivity and safety of underground metal mines by developing new ground control technology on backfill properties and placement, computer design utilization, and bulk mining at depth.

Background

Under the 5 year Canada-Ontario Mineral Development Agreement, $3.55M was allocated to the Productivities and Technology Program. The program has, as its objective, research leading to increased mine efficiency and productivity while maintaining or improving safety in the Ontario minerals industry.

A meeting was held in January 1986, at Timmins, Ontario, with senior technical representatives from the Ontario mining industry to identify research needs and priorities. At the meeting, research to develop new technology in backfill properties and placement, computers in mining and bulk mining at depth were identified as priority areas.

Several research contracts were developed and awarded to address the stated needs of the industry.

Achievements

During the 1987/88 fiscal year, contracts to study the behaviour of dense fill and the liquifaction potential of dense fill were completed. Reports on the findings will be distributed as soon as copies can be printed.

Most of the preliminary equipment needed for MRL's new Sudbury Backfill Laboratory has been purchased. Arrangements with Laurentian University for the space have been completed and the lab is expected to be commissioned by the summer of 1988.

The underground backfilling work at the Denison Mine is complete, and the pillars in the test area are being monitored to determine the effects of backfill on their properties. The other long-term projects are continuing and are on schedule.

All research projects were reviewed during meetings on June 2 and 3, 1987, at CANMET's Bells Corners Complex. About 25 mining industry representatives attended, as well as 7 USBM staff who were attending other meetings concerning the exchange of technical information and data between Canada and the U.S.A.

MINERAL RESERVES ASSESSMENT

MINERAL RESERVES

Objectives

The project objectives are to determine and report annually on Canada's economically mineable Reasonably Assured and Associated Inferred Resources of uranium; to determine the ore reserves of specified mineral deposits to meet departmental information requirements; and, to develop new and/or improved existing ore reserve evaluation methodologies for the assessment of mineral reserves and related economic values.

Background

In 1974 the need for an expanding role for nuclear power in Canada was recognized. Accordingly, a policy was initiated to encourage exploration for uranium. In addition, the Uranium Resource Appraisal Group, (URAG), was established with the mandate to maintain a continuous, reliable and uniform assessment of Canadian reserves, resources and productive capability, as a basis for the nuclear related aspects of the government's energy policy. In support of URAG, three departmental sub-Committees were created: the Sub-committee on Reasonably Assured Resources (Measured and Indicated reserves); the Sub-committee on Estimated Additional Resources (Inferred, Prognosticated and Speculative resources); and the Sub-committee on Economics of Supply and Demand. The Ore Reserve Assessment Group, (ORAG), established within the organization of the Mining Research Laboratories (MRL), is responsible for the leadership of the Sub-committee on Reasonably Assured Resources and participates in the work of the other two sub-committees.

Since its inception in 1974, ORAG, on behalf of URAG, has assembled primary assaying and sampling data on relevant uranium deposits on a continuous basis. At the same time, its staff has developed required procedures for computer storage of the assembled data, as well as a variety of computer-applicable assessment methodologies for evaluation of mineral reserves and resources. ORAG produces a major internal confidential report annually, which contains the current status of Reasonably Assured Reserves and Associated Inferred Resources of uranium and thorium in all developed deposits in the country, regardless of whether or not these are actively producing or dormant. The report also contains the actual, or estimated projected production capabilities of these deposits.

Achievements

During 1987/88, ORAG prepared its internal confidential report, and submitted it to URAG. In addition, MRL assessed the Inferred Resources of uranium, associated with the Reasonably Assured Resources, for the use of the Mineral Resource Appraisal Secretariat/Mineral

Resources Division of the Geological Survey of Canada, which organization is responsible for leadership of the Sub-Committee on Estimated Additional Resources of uranium.

Also during 1987/88, ORAG continued its data collecting activity of current primary assaying and sampling data from active uranium mining and development companies. The collected data are either already encoded or are being encoded at the present into ORAG's computer data files. These continuously-updated computer data files are utilized both in the preparation of ORAG's next internal confidential report on uranium for 1986, as well as in various other studies, specific to individual uranium deposits. In the summer of 1987, data from nearly 900 combined underground drillholes were collected from an operating uranium mine to establish a new file. The data includes uranium, thorium and yttrium assays. The file will be used to prepare uranium and yttrium ore reserve estimations, as well as a basis to investigate the quantitative interrelationships and mineralization styles of the three elements in the same orebody. At the present, the ORAG computer data files contain the description of 1179.76 km of diamond drilling, 350,291 geological information items, and 238,888 assays.

In the late fall of 1987 ORAG personnel, in close co-operation with the consultants of a major uranium mining company, prepared a detailed multi-cutoff ore reserve calculation of a large uranium deposit. The results of this calculation will form the groundwork of the company's feasibility study and development plans of the deposit. The methodology of the same ore reserve calculation is the backbone of a confidential report to URAG and to the company. This report is currently being prepared.

A member of ORAG, André Boyer, was the MRL coordinator of the ACFAS annual meeting in May 1987. He organized and supervised the visit of ACFAS participants at the Bells Corners Complex, as well as collaborated as co-author in the preparation of a paper for the Earth Science Section meeting of the ACFAS conference. Mr. Boyer also acted as MRL coordinator for the CANMET Val d'Or seminar, February 1988.

Another member of ORAG, Dennis Walsh, was elected as Chairman of the Ottawa Branch of the Canadian Institute of Mining and Metallurgy for 1987/88.

ORAG members also participated in the preparation of a confidential paper on ore blending and mill recovery optimization with respect to a multi-metal, open pit mining project.

MINING RESEARCH LABORATORIES
1987
Reports Listing for CMTL

CANMET SPECIAL PUBLICATIONS

SP 87-5	Index of Mining Technology Projects 1987. Répertoire de Projets en Technologie Minière 1987	N. Billette P. Lacourse

MRL PUBLICATIONS

87-04(TR)	Post-failure multi-stage triaxial strength determinations using a computer controlled servo-hydraulic test system	B. Gorski
87-05(INT)	Visites de Mines 1986 Mine Site Visits	R. Clarke P. Lacourse
87-06(TR)	Monitoring of borehole deformation of Niobec Mine - A progress report	G. Herget F. Kapeller
87-07(OPJ)	Computer simulation of a room-and-pillar mining system in a Canadian potash mine	Y. Yu C.G. Ong P. Mottahed
87-08(TR)	A User Manual for the CADDE/IOV Computer Program to optimize drill log data entry and validation into a computer data bank	A. Boyer R. Boyle
87-10(OP) E	Summary of 24 Surface Crown Pillar Case Studies	M. Bétournay S. Nantel D. Lessard
87-10(OP) F	Sommaire de 24 histoires de cas de piliers de surface	M. Bétournay S. Nantel D. Lessard
87-14(OPJ)	A case study of surface crown pillars: The Niobec Mine	M. Bétournay Y. Yu
87-22(OPJ)	Impact de variables quantitatives sur les accidents en souterrain: analyse multifactorielle	N. Billette M. Laflamme R.J. Keyes L. Marcoux
87-23(OPJ)	Recherche sur les liens entre boni et accidents: étude préliminaire	N. Billette J.L. Chouinard
87-25(TR)	IMPRESSLIB Fortran impress interface library	N. Toews A.S. Wong

87-29(TR)	Index testing of fractures in URL diamond drill cores (Level II concept assessment draft report)	A. Annor R. Jackson
87-31(TR)	Results of direct shear tests on small block cold spring quarry specimens	R. Jackson A. Annor
87-32(OPJ)	CANMET role in mine equipment development	N. Billette
87-33(INT)	Post-failure uniaxial strength determinations using a servo-hydraulic test system	B. Gorski
87-37(OP)	Influence of various parameters on underground accidents: A multifactorial approach in Quebec Mines	N. Billette M. Laflamme
87-39(OPJ)	Eléments géomécaniques de récupération de piliers de surface	M. Bétournay
87-40(OP)	Equipment development trends: CANMET past and present involvement	N.R. Billette
87-44(OP)	Continuing education needs survey results	N. Billette J. Udd
87-45(TR) E&F	English-French Lexicon of surface crown pillar related terms/Lexique français-anglais de la terminologie reliée aux piliers de surface	M. Bétournay
87-46(OPJ)	Mining in the 21st Century	J. Pathak
87-47(INT)	Frictional properties established by confined shear test method	M. Gyenge
87-48(TR)	International index of Mining Technology Projects	R.J. Welwood
87-52(INT)	Nuclear fuel waste management program concept assessment document - Geotechnical studies at Whiteshell Research Area (RA-3). Rock Properties, March 2, 1987	Edited by: T.J. Katsube J.P. Hume
87-54(INT)	Documentation of TEKPS	N. Toews A.S. Wong
87-55(OP)	Communication systems for isolated areas in mines Phase II	S. Soneff S. Vongpaisal
87-63(OP)	Impact of various parameters on underground accidents in Quebec Mines: A multifactorial approach	N.R. Billette M. Laflamme

87-70(OP)	Suivi géotechnique du fonçage par tunnelier à la Mine Donkin-Morien, en Nouvelle-Écosse	J.L. Gilby C.M.K. Yuen T.R.C. Aston M.C. Bétournay
87-80(TR)	Post-failure uniaxial testing on URL1 core	R. Jackson
87-81(TR)	6th ISRM congress promotion and S. American lecture tour	G. Herget
87-90(TR)	Preliminary geomechanical assessment of the Dumagami Mine	M. Bétournay
87-91(TR)	Preliminary geomechanical assessment of the Eldrich-Flavel Mine	M. Bétournay
87-92(TR)	Coring of Soft Soil-Like Rock Materials	M. Bétournay C. Mirza K.C. Lau
87-94(INT)	Geotechnical studies at East Bull Lake research area (RA-7)	Edited by: A.G. Latham
87-96(TR)	Stability assessment of S-L-102-17 sill pillar of the Niobec Mine, Chicoutimi, Québec - Part III	Y. Yu A.S. Wong S. Vongpaisal N. Toews
87-97(IR)	Review of cutting technology for evaporite mining	G. Knight
87-98(IR)	Proposal for development of cutting technology for evaporite mining	G. Knight
87-99(IR)	Proposal for dust generation and engineering parameter study in rock loading	G. Knight J. Pathak
87-100(OP)	Capabilities, limitations and the use of the Georoc computer package	Yang Yu
87-103(IR)	Review of dust control and engineering parameters in loading	G. Knight
87-104(TR)	Anisotropic properties study of Lac du Bonnet granite specimens: Report No. 4	R. Jackson

87-107(TR)	Computer blast design programs for underground stopes (User manual for programs VCRM, LDBB and PGRAPH)	P. Lacourse R. Boyle
87-116(INT)	Modal analysis of a pinkish granitic rock sample from Cold Spring Quarry, near Pinawa, Manitoba	A.S. Wong
87-120(INT)	PSPRINT Postcript laser print utility	N. Toews A.S. Wong
87-126(OPJ)	Orebodies and mine planning 3-D modelling, Phase I: Geological contours and ore reserves assessment	A. Boyer N. Billette R. Boyle
87-128(TR)	Results of parametric studies performed for the development of support design guidelines	M. Gyenge
87-129(INT)	Instrumentation program at Swiss Institute of Technology and Grimsel Test Site	G. Herget
87-135(OP) E	Exploitation in small mines - An outside view presentation	J. Pathak J. Udd
87-135(OP) F	L'exploitation des petites mines souterraines; vues de l'extérieur	J. Pathak J. Udd
87-136(OP)	Diamond drilling of rigid soils and altered rock materials	M. Bétournay
87-137(TR)	Evaluation of support systems for weak rock masses	M. Bétournay
87-140(INT)	Rapport des visites de mines du sud-est de la Colombie Britannique dans le cadre de la collecte d'informations pour le répertoire de projets en technologie minière	N. Billette R. Rouleau
87-144(TR)	X-ray diffraction analysis of mine airborne dust - An interference problem at Helmo Gold Mines	G. Knight W. Zawadski
87-145(TR) E	Overview of Mining Research Laboratories Activities	A. Boyer P. Lacourse
87-145(TR) F	Tour d'horizon des activités des laboratoires de recherche minière (narration du film vidéo)	A. Boyer P. Lacourse

87-146(OPJ)	Les logiciels des LRM pour les mines souterraines	R. Boyle A. Boyer S. Vongpaisal P. Lacourse
87-148(IR)	Review of cutting technology for evaporite mining	G. Knight
87-149(IR)	Proposal for development of cutting technology for evaporite mining: Part 1: Review of Mining Company in-house research	G. Knight
87-150(IR)	Proposal for dust generation and engineering parameter study in rock loading	G. Knight J. Pathak
87-151(IR)	Review of dust control and engineering parameters in loading	G. Knight J. Pathak
87-152(IR)	Proposal for wetting ore standing in stopes	G. Knight
87-153(IR)	Proposal for tests of wetting agents for dust suppression on sulphide ores	G. Knight
87-154(OP)	L'instrumentation dédiée au contrôle des terrains	G. Herget M. Bétournay
87-158(TR)	Uniaxial mechanical and dynamic properties of anomolous rock samples from Lac du Bonnet, Manitoba, Report #1	R. Jackson
87-159(TR)	Artificial support (including backfill)	A. Annor R.W.D. Clarke P. Lacourse
87-162(TR)	Interface for 12-Bit Squirrel Data Logger to read vibrating wire sensors	F. Kapeller
87-163(TR)	Pocket size frequency counter for reading vibrating wire strain rings and vibrating wire exciter units	F. Kapeller
87-168(INT)	Documentation of TEKPS (See MRL 87-54)	N. Toews A.S. Wong
87-169(TR)	Strength determinations of Montauban Mine rocks	B. Gorski M. Little M. Bétournay

87-170(TR)	Published underground-environment dust reports CANMET/Mining Research Laboratories, 1960-1987	G. Knight
87-176(TR)	The characterization of the Montauban Mine rock mass	M.C. Bétournay
87-179(R)	Quartz analysis x-ray diffraction with computer control-computer programs and explanations	G. Knight
87-183(INT)	Répertoire de projets en technologie minière: Guide de l'usager	P. Lacourse
87-185(TR)	Instrumentation for ground control	G. Herget
87-188(TR)	Comparison of Montauban rock types with various strength tests	M. Bétournay
87-189(TR)	Tensile strength of Montauban mine rocks	M. Bétournay

EXPLOSIVE ATMOSPHERES

Highlights

The Dust Explosion Control Program, involving 36 participants in the Canadian mining industry, has made considerable progress during the past year. Plans were made at the January 1988 meeting to accelerate the rate of R&D by hiring a professional to oversee self-financed experiments at 5 operating properties where dust explosions occur at a high frequency.

In addition to further in-house laboratory equipment development related to dust explosion phenomena, a contracted-out "synthesis" study has been completed which will be distributed to the industry and presented at the May 1988 CIMM Conference in Edmonton. Also, in-house progress in the fundamental understanding of sulphide ore dust explosion phenomena has been made, involving the determination of the explosibility of "pure" sulphide ore compounds and example ore dusts.

Unusually good progress in the field of Diesel Emissions R/D has resulted during the past year from the simultaneous fruition of a number of initiatives made in the past and summarized as follows:

(1) completion of CSA Standard M424.1 governing flameproof diesel engine application underground involving the CANMET AQI for ventilation determination;

(2) initiation of technology transfer for the CANMET venturi exhaust scrubbing system with Engine Control Systems (ECS) of Aurora, Ontario;

(3) completion of the second year of successful NRC/IRAP/PILP commercialization of the ceramic exhaust filter with ECS. One year remains;

(4) action taken to consolidate results of animal studies which: (a) incriminate soot as the generator of tumours for ultimate presentation to the industry, and (b) justify CANMET'S concentration on the development of devices for soot removal;

(5) completion of an encouraging first phase of a significant CANMET/Noranda air quality study featuring the use of CO2 measurements as a surrogate for the several diesel emissions pollutants of concern;

(6) conception of the theoretical bases for an underground environment monitoring and quality control technology for transfer in subsequent years;

(7) completion of plans for an important air quality study to be undertaken in collaboration with a major Ontario mine.

Progress in the Wire Rope Hoisting Technology project was also very satisfactory. This was especially true in the area of in-house efforts to assemble and analyze background information. Also, considerable progress was evident in the good relationships established with CANMET/MRL's partners in this work, i.e., the United States Bureau of Mines and the Ontario Ministry of Labour.

FIRE AND EXPLOSIVE HAZARD R&D

As a result of a fatality from the sulphur dioxide gas produced by a sulphide ore dust explosion in October 1985 at Geco Mine, Manitouwadge, Ont., there has been a increasing recognition by the mining industry that better methods must be developed to eliminate, or at least mitigate, the effects of these explosions. Apart from presenting a significant safety hazard, they also cause considerable loss of productivity. The proceedings of a workshop on sulphide dust explosions held at Manitouwadge in October 1986 was published in 1987 by CANMET, in cooperation with Noranda Minerals, Inc. CANMET has played a lead role in organizing meetings of the industry/government/academic group on sulphide dust research, which was formed as a result of the Manitouwadge meeting. An extensive laboratory study of the explosibility of sulphide ore dusts has been carried out jointly with Noranda Research; the results will be presented in a paper to the CIM Annual General Meeting in May 1988.

A study of the explosibility of Canadian coal dusts is currently underway, as part of the work funded under the Interdepartmental Panel on Energy Research and Development. Dust explosibility is a problem not only in underground coal mines but also in coal preparation plants.

The classical Hartmann apparatus for measuring the explosibility of dusts has been upgraded so as to conform to the latest standard, as well as providing features not available elsewhere. A larger explosion vessel, the "20 L", is expected to become the world standard within a few years. CEAL commissioned its 20 L vessel this year, which will be used for most studies in the future.

Two cost-recovery studies were carried out for industrial clients. In the first study, the explosibility of phenolformaldehyde dust was measured in order that the company could do a hazard assessment of their operation. In the other study, the minimum ignition temperature of potato starch was measured to explain the origin of a fire.

Three external contracts were awarded this year: a state-of-the-art analysis of sulphide dust explosions; preliminary development of an instrument package to measure sulphide ore dust and sulphur dioxide in mines; and a continuation of the study of dust explosion fundamentals.

DIESEL EMISSIONS CONTROLS

In general there have been three major objectives for these studies:

(1) the development of a comprehensive criterion (i.e. the Air Quality Index - AQI) by which to judge the toxicity of the several noxious components of diesel exhaust;

(2) the development of diesel emissions reduction devices; and

(3) the monitoring of air quality in dieselized underground workings.

Canadian Standard CSA M424.1 (see item 14 on report list), describing the requirements for explosion-proof diesel machinery for coal mines was successfully ballotted and is now in the printing process (March 1988). It incorporates the CANMET air Quality Index (AQI) as the means of establishing appropriate ventilation for such machines. This standard having been completed, a start on the metal mine version will begin early in 1988.

With respect to emissions reduction research and development, the past year has seen the following major thrusts:

Engine Control Systems (ECS) was the successful respondent to a request for proposals to exploit the CANMET Venturi Scrubber emmissions reductions system. This system involves water injection and, therefore, more than fulfills the traditional coal mining needs with respect to both health and safety. As a consequence, there is a significant projected market in the US coal industry which has been dieselizing rapidly in the past two years. A major US coal producer requested a CANMET design to assess in their own dynamometer laboratory. Formalization of a licensing agreement with ECS will take place in 1988.

A 50/50 cost-shared $10,000 study of a turbo-charged/water-cooled Caterpillar 3304 engine developed specifically for the mining industry was evaluated in a joint Crothers (Canada)/CANMET MRL testing program. The result was a high power package in a relatively small volume - an attractive combination for mining application. A joint paper is planned in 1988 to report the results to the industry-at-large.

Approximately two years of the three year NRC/IRAP(PILP) program of commercialization of the ceramic diesel particulate filtration technology, have been completed. This involves a total of $300,000 equally shared by ECS and NRC. The success of the first detailed program of application to machines in Noranda's Brunswick mine has resulted in the operator's decision to make the technology available mine-wide. Application to five major Ontario mines (INCO, Falconbridge, Kidd Creek, Rio Algom and Denison) is now in progress. Ceramic units are now in operation in mines in the U.S.A. and Australia as well as Canada. The first INCO installation is reported to have been operating successfully for 9,000 hours. An important paper has been prepared to bring the world mining community up-to-date on these developments.

In recognition of CANMET/MRL/CEAL's important contributions to emissions reduction technology, a CANMET scientist was invited to participate in the US technology transfer sessions in Louisville, Kentucky and Denver, Colorado during March of 1987. Three CANMET papers were included in USBM Information Circular #9141, published for those occasions.

With respect to progress made in the area of health effects of diesel exhaust, I.W. French and Dr. Anne Mildon have received an unusually important contract to evaluate the impact of 8 recent animal studies (rats and mice) on present regulatory limits. Soot has been clearly identified as the major contributor to cancer production in the animals and the desirability of its removal confirmed. Consequently, CANMET/MRL's concentration on the development of soot reducing devices has been justified. The contract will answer the questions: (1) is the AQI = 3 maximum still a valid limit for soot-bearing exhaust? and, (2) is the recommended soot limit concentration of 1.5 mg/m3 still suitable in view of statements suggesting that a level of 1.0 mg/m3 may result in a cancer excess in humans of two percent?

These points, and the result of an INCO/Labour study suggesting a slight increase in cancer rate of miners relative to the general population, indicates that a careful look at present practice is warranted. CANMET/MRL will undertake to find a consensus on this matter during 1988 after the results of the I.W. French contract are tabled. This general issue has been reported to the Val d'Or and Ontario mining communities by presentations at the CANMET Seminar of February 25, 1988 and the Ontario Mining Association of March 2, 1988 respectively.

A report outlining the adequacy of the performance of hi-vol samplers vs personal samplers for assessing Polynuclear Aromatic Hydrocarbon (PAH) levels in mine atmospheres, was completed and the results communicated to the major industries in the Sudbury region where the measurement were made, plus others.

In the area of assessment of underground environment air quality, several studies were undertaken and new initiatives made, as follows:

A study of soot sampling in a simulated mine environment was undertaken to confirm the performance of standard cyclone pre-separators attached to the intake side of the soot sampling cassettes used to gravimetrically determine respirable combustible dust. A MRL report points out that the cyclone makes no difference to the reading, confirming the long-held view that soot is 100% respirable.

A CANMET team of 3, along with Noranda Research personnel, undertook the assessment of CO_2 as a surrogate measurement for all diesel exhaust components in the Brunswick Mine at Bathurst, New Brunswick in conjunction with a shared New Brunswick Mineral Development Agreement ($57,000/Noranda and $107,000/CANMET) for a total of $164,000. The first result was very encouraging. A further investigation will be undertaken before this very important conclusion is accepted and communicated to the industry. This study has far-reaching consequences for reduced cost environmental monitoring and ultimately automated quality control of mine ventilation systems to effect considerable operating savings.

Mathematical definition of two fundamental principles: (1) relatively simple CO_2 and ventilation measurements are sufficient to define overall fuel consumption, and vehicle load factors and, (2) CO_2 measurement to control air recirculation in order to maintain air quality were completed in 1987/88. These, along with the CO_2 surrogate principle, will form the basis of a monitoring and control technology for transfer to the industry in subsequent years.

After completion of in-house evaluation of the CONSPEC Senturion Mine Monitoring System, a three-year program for installation of the CANMET/MRL CONSPEC system in the Domtar Salt Mine Goderich, Ontario, was formulated. The system has been furnished with additional equipment and sensors which will permit the sensing of methane concentrations, allowing action to be taken to prevent the accumulation of explosive concentrations in order to improve the safety of the operation. System installation began during April of 1988. Diesel sensor will be added in the second year. Perhaps the implementation of this new technology can be investigated in conjunction with this joint study. Full disclosure has been negotiated for the benefit of the mining industry. The company will reimburse CANMET $65,000 for participation in this joint venture.

Plans for an important air quality study to be undertaken in collaboration with a major Ontario mine, have been completed. The study is to last for three years. Because it has been agreed that full disclosure to the industry in general will result, the company will reimburse CANMET for 50% of the $400,000 estimated total cost of CANMET's contributions.

A departmental van has been transferred to MRL/CEAL to function as a mobile lab for mine environment monitoring investigations.

1987/88 has been a very productive R&D year.

WIRE ROPE AND HOISTING TECHNOLOGY PROJECT

Under the auspices of an "umbrella" Memorandum of Understanding between CANMET and the United States Bureau of Mines, dated April 2, 1981, joined by the Ministry of Labour of the Province of Ontario as a third party, several cooperative projects have been undertaken. Two of these have been handled by CANMET's Mining Research Laboratories. The one on diesel exhaust filters has now been successfully completed. The other, on Wire Rope and Hoisting Technology, was commenced in September 1983, and is now being handled by MRL's Explosive Atmospheres Research Laboratory. Its present termination date is set for September, 1988. However, another three-year extension is currently being prepared.

1987/88 was another year of fruitful and harmonious cooperation between the three signatories. On MRL's behalf, the year's highlights included:

(1) the sixth joint advisory panel meeting, this time organized by MRL, and held at MRL's Elliot Lake Laboratories;

(2) preparation of a contractual project, designed to comparatively examine a range of electro-magnetic wire-rope test instruments under strictly controlled conditions, both in the field and in the laboratory; and

(3) initiation of an in-house project, designed to collect and to analyse the considerable amount of background information available from provincial mining authorities, and in particular, from the Ontario Ministry of Labour's Rope Testing Laboratory.

An unusual aspect of the joint meeting at Elliot Lake was the presence of 23 "observers" from the Canadian mining industry and provincial mining authorities. The purpose was to make the work of this international group more widely known to those whose activities are most directly, and beneficiently, affected by any results that may be achieved. This work involves inter alia:

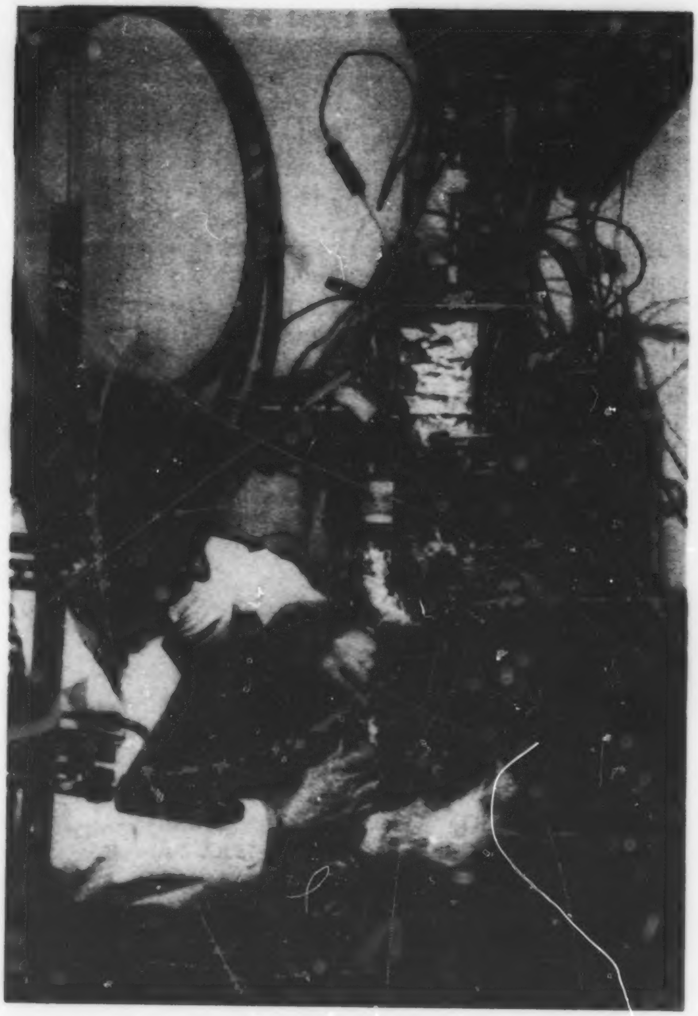
- cooperation with ASTM's Committee E-7 on non-destructive testing;
- a study of the effects of zinc-socketing temperatures on high-tensile wire ropes;
- an evaluation of lubricants, of resin terminations, and of Kevlar ropes;
- a study of the lessons that can be drawn from specific hoisting incidents; and
- a study of the results achieved by the USBM scientists in their laboratories.

CANMET's proposed contractual work advanced to the point that responses could be invited to a Request for Proposal. No contractor would, however, be chosen as yet.

Finally, good progress was made with the in-house work on research into background information. A large amount of valuable information was obtained from a number of sources. Equally important, excellent contacts were established with both the mines and provincial regulatory authorities. The latter contacts include membership, in an advisory, liaison, and observer capacity, on the Review Committee established by the Province of Manitoba to monitor their own contract on wire-rope electro-magnetic instrument evaluation.

EQUIPMENT SAFETY CERTIFICATION

EXPLOSIVE ATMOSPHERES



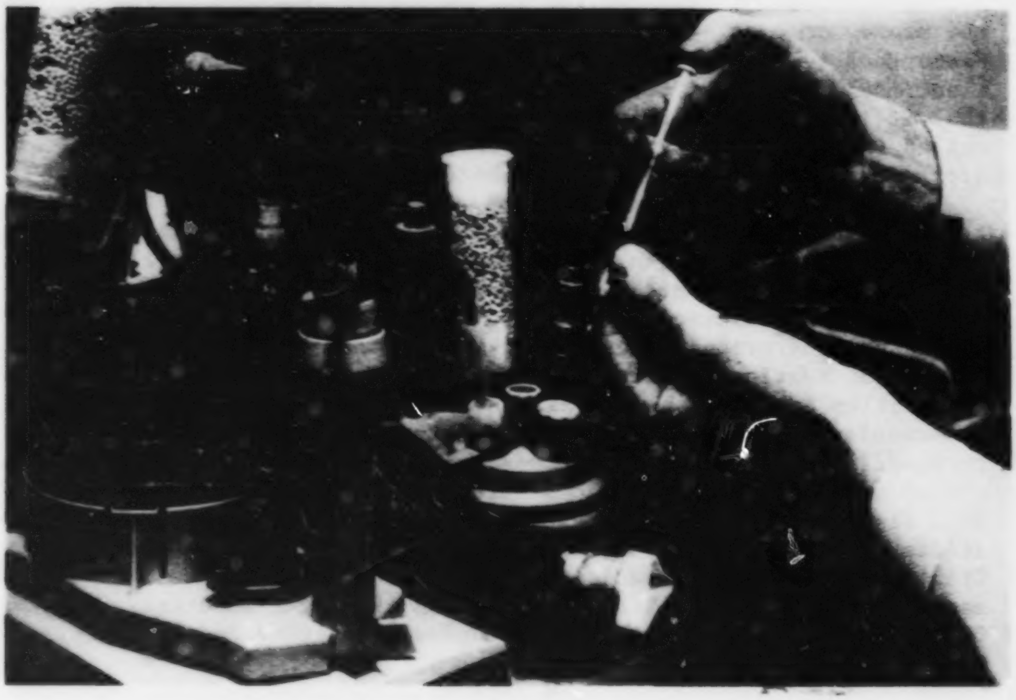
Mike Boyle, Technologist/CEAL, prepares the fire resistant hydraulic fluid test apparatus for testing

Highlights

During the fiscal year, a total of 75 certification projects were processed, with 32 certificates being issued. Cost recovery billings reached a record high level (on the order of $90K as compared to approxmately $68K last FY) due to some very large conveyor belt certification files being processed. In the contract testing area, a total of 88 files were processed, with 59 of these jobs being performed on behalf of the Canadian Standards Association.

The greatest interest this year was in the conveyor belt test facility, with the large-scale conveyor belt fire test receiving the most attention from the industry. This interest probably derives from the fact that the test truly represents a mine fire situation. The facility was under close scrutiny by the Ontario Ministry of the Environment and Environment Canada with respect to the smoke produced by the facility during testing operations. A consultant will be studying the facility with a view to recommending a suitable emissions control strategy.

EXPLOSIVE ATMOSPHERES



Sample of fire-resistant hydraulic fluid being injected into the Kart-Fisher Apparatus which measures the percent of water in the sample

EQUIPMENT CERTIFICATION AND TESTING
QUALITY ASSURANCE
STANDARDS DEVELOPMENT

Objectives

The main objectives for this activity are to provide a certification service for equipment and materials used in underground mines in Canada. The equipment is mainly for use in coal mines where there is a constant danger of explosion due to the presence of methane gas and coal dust. Electrical equipment and diesel powered equipment operating in this environment must be designed so that it will not become a source of ignition for the explosive atmospheres generated by the mining of coal. This normally means that it must be built to Flameproof (explosion-proof) Standards. In the case of low energy electrical signalling devices, the energy available can be limited so that it is incapable of igniting the gas or dust. This technique is called intrinsic safety. In addition, gas detection devices must give accurate readings so that the gas hazard can be reliably assessed.

CEAL has built and maintains facilities for assessing and testing equipment to all of these rigid requirements. In addition, it has facilities for testing the emissions from diesel engines so that some certifications have been awarded to non-flameproof diesels for use in non-gassy underground mines. As this is the only facility of its kind in Canada, testing is also performed for other Canadian certifying authorities such as Canadian Standards Association, Canadian Gas Association and Underwriters' Laboratories of Canada. Development testing is also performed for Canadian companies working in this field.

Fire is a very serious matter in an underground environment because it can foul the air and block exits from the mine. For this reason, CEAL performs testing and issues certificates for various fire-resistant materials for use in all underground mines. These materials include Conveyor Belting, Electric Cables, Hydraulic Fluids and Ventilating Duct Material.

Background

In 1950, the Provincial Ministers of Mines across Canada, at the the insistence of the Provincial Inspectors of Mines, requested the Federal Government to set up a certification service for Electrical Equipment for use in underground coal mines. This was to assist the provincial inspectors in the performance of their mine inspections and to assist Canadian manufacturers to produce equipment without having to go to a foreign laboratory for testing and certification.

The "Certification Laboratory" was set up in 1955 by Mines and Technical Surveys (now EMR Canada). After a few years, this small laboratory was asked to expand their activities to include Fire-Resistant Conveyor Belting. Later, they were asked to include underground diesels, then other fire resistant materials, until today there are a total of twelve different categories for which certificates are granted.

When a new category is established, the standard of another country is normally used temporarily because of the absence of a Canadian equivalent. As we do not feel comfortable using the standard of another country or unilaterally setting our own requirements, we attempt to write a Canadian Standard on the subject at the earliest possible time. These standards are normally published by a recognized Standards Writing Body (SWB) but much of the input and the research and development for these standards comes from CEAL. We have been instrumental in setting up a new Standards Steering Committee within the framework of the Canadian Standards Association for Electrical/Mechanical Mine Safety, which now fills most of our needs for new standards. These standards must be "consensus" standards and, in addition, because Canada is a signatory to the GATT agreement, they must not be written in a manner that will restrain foreign trade. This has led us to participate in International Standards activities.

CEAL staff serve on several committees of the International Standards Organization (ISO) and the International Electrotechnical Commission (IEC) and presently holds the Chairmanship of IEC Technical Committee 31, which is responsible for all the International Standards for Electrical Equipment for use in Explosive Atmospheres.

Achievements

Testing and certification activities continued at approximately the same pace as the previous fiscal year, although cost recovery billings were up significantly. The human resources of the laboratory were fully utilized, with some additional support being provided by student assistants and industry secondments. Vacancies in one engineering and in one engineering support position prevented the testing backlog and turn-around times from being reduced to acceptable levels for much of the year.

There were two requests made to CEAL staff to provide expert witness testimony in legal proceedings during the fiscal year. One case involved criminal charges relating to the use of explosive propane mixtures in a manufacturing plant, and the other a civil suit for damages in a fire where flammable vapours were alleged to have been involved. CEAL also completed a study on behalf of Transport Canada involving the ignition sensitivity by electrical means, as a function of temperature, of various blends of methanol automotive fuels.

Quality assurance inspections, carried out on behalf of EMR by Canadian Standards Association inspectors, continued at a steady pace. All offshore manufacturers of EMR certified products have been inspected once by a CSA inspector representing EMR, as have most North American manufacturers.

Standards activities continued at a normal pace. There were no new standards initiatives taken, but revision work continued on a number of documents.

MINING RESEARCH LABORATORIES
1987
Reports Listing for CEAL

CANMET SPECIAL PUBLICATIONS

SP 87-3	Sulphide dust explosion - Proceedings of a workshop sponsored by Noranda Minerals Inc., GECO Division at Manitouwadge, Ontario, October 23 and 24, 1986)	E.D. Dainty L.B. Geller

MRL PUBLICATIONS

87-03(TR)	Laboratory confirmation of methods of respirable combustible dust determination	D. Dainty J. Ebersole J. Vallières M. Gangal
87-18(OPJ)	Tests of a prototype Venturi scrubber system	P. Mogan D. Dainty
87-26(OP)	Testing of fire-resistance of materials used in Canadian Mines	K. Mintz
87-28(OP)	Process control in hazardous locations	J. Bossert
87-38(INT)	Canada/New Brunswick Mineral Development Agreement, Task II.14: Evaluation of improved methods for the non-destructive testing of mine-shaft wire-ropes - A project proposal	L. Geller J. Udd
87-43(INT)	Visit to Japan, Feb. 9-27, 1987	K. Mintz
87-71(TR)	Flame tests for flexible ventilation materials and mine brattice cloth-operating procedures	N. Sarin
87-74(TR)	Operating procedures - flame tests on rigid ducts used for mine ventilation	N.K. Sarin
87-86(OPJ)	Mine environment monitoring system and sensor performance evaluations	M. Gangal E.D. Dainty
87-89(TR)	The CEAL Propane Gallery Test	K. Mintz

EXPLOSIVE ATMOSPHERES

Ken Judge, technologist/CEAL, performs flammability testing of materials using the Oxygen Index Test Apparatus

87-124(TR)	Instrumentation of Hartmann & 20L dust explosibility tests at CEAL	K. Judge
87-125(OPJ)	Status of in mine diesel particulate filter trials	F. Enga D. Dainty
87-133(OP)	Improvement of diesel engine performance from the standpoint of gas and soot emissions reduction	D. Dainty
87-138(TR)	Dust explosibility tests: Hartmann apparatus	K. Mintz
87-139(TR)	Derivation of the brake specific ventilation equation and an operating load factor expression relevant to the use of diesel machinery underground	D. Dainty
87-157(TR)	Derivation of the ventilation recirculation equations relevant to underground dieselized machines	E.D. Dainty
87-178(TR)	Environmental law and its impact on the CANMET conveyor belt test facility	G. Lobay
87-181(OPJ)	Mutagen levels in the treated and untreated exhaust of diesel engines in common use in underground mining	J.P. Mogan E.D. Dainty K.C. Westaway A.J. Horton
87-191(OPJ) E	Certification of fire-resistant materials for use in underground mines	J.A. Bossert
87-191(OPJ) F	Certification des matériaux résistant au feu utilisés dans les mines souterraines	J.A. Bossert

ELLIOT LAKE LABORATORY

Highlights

Now in its third year of operation, the new Elliot Lake Laboratory continues to attract many visitors and thus serves to indicate in a direct way the commitment of CANMET to the mining industry. Among the visitors have been primary and secondary school student groups as well as mining engineering classes.

The major activity continues to be the rockburst research program. This 5-year program has tripartite funding from the Federal and Provincial Governments and the mining industry, with members from each on the technical and management committees. A great deal of progress has been made on this well-managed program.

Underground environmental studies cover the measurement and means of control of radiation, ventilation and mine dust.

Surface environmental research is focused on reactive acid tailings under the CANMET/Industry/Provincial Governments program (RATS). Here, the technical working group and steering committees are led by industry members, with representation from all participants across Canada.

Technology transfer is facilitated by the close contacts that are maintained with the mining industry.

MINE AND REGIONAL STABILITY

Background

New mines rarely have ground control problems, and those that do occur tend to be local in nature. However, towards the end of a mine's life the workings usually are extensive and even local instability can propagate into regional instability affecting the whole mine or a very large section of it. In recent years there have been several examples where attempting to recover the last 10% of ore reserves has resulted in multiple rockbursts and/or caving, which then resulted in abandonment of a section or closure of the complete mine. These regional problems are especially prevalent at depth in a high stress environment.

Objective

To evaluate pillar stability on a local and regional scale in Canadian hard rock mines; to determine the stress fields around these mines and to evaluate parameters controlling stability.

Summary of Achievements

Field stress measurements were taken at the Niobec Mine near Chicoutimi, Québec. The mine used a blasthole stoping method in an irregular room-and-pillar pattern. Measurements were taken at a depth of 260 and 305 meters, and indicated a vertical stress consistent with the expected gravitational stress. Horizontal stresses averaged twice the vertical stress, again consistent with other stress measurements in the Canadian Shield.

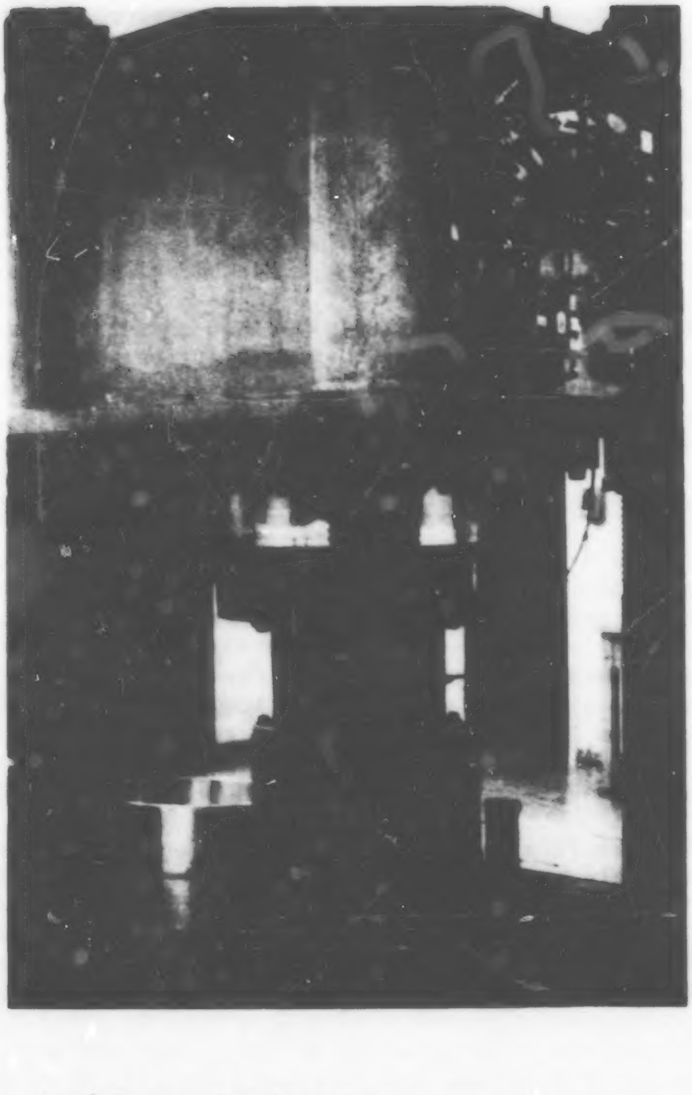
At the Macassa Mine of Lac Minerals Ltd., Kirkland Lake, over 400 rockburst incidents were evaluated. In the context of rockbursts, high ground stresses, mining geometry, critical pillar configurations and the presence of high-strength rocks were found to be significant factors. In the active and mined-out workings pillar bursts were the most common rockburst mechanism.

Field stress determinations were carried out at the Kidd Creek Mine, Timmins. From present and previously obtained stress data, pre-mining ground stresses were evaluated for depths between 488 and 1382 meters.

Ground stresses were measured at La Mine Bousquet, Québec to provide stress data for shaft design purposes.

A comprehensive stress determination program was completed at the Campbell Red Lake Mine, Ontario. Pre-mining stress gradients were established for this rockburst-prone mine providing essential information for numerical modelling. The results also indicated the effects of the main structural features on the stress regime: the maximum horizontal stress is perpendicular to the various ore zones. In addition, pillar stresses were measured at rockburst affected mine sites for stability analysis.

ELLIOT LAKE LABORATORY



Load frame of Elliot Lake Laboratory Rock Press

Preparations were made for multi-specimen testing in the 18 MN press; calibration of the press and a 750mm diameter aluminum ring, as well as preparation of steel load cells and core specimens, were completed. Data acquisition program development and additional laboratory work, required for testing purposes, are still in progress.

ROCKBURST RESEARCH

Background

Since 1982, rockburst activity has increased dramatically in Ontario mines. At present, 15 mines have experienced rockbursts. The end results have been fatalities, mine closures, layoffs and loss of ore reserves. In 1985 a major rockburst project was initiated in Ontario. The project covers five years at a cost of $4.2 million with tripartite funding from the Federal and Provincial Governments and the Ontario Mining Industry. Management and Technical Committees, consisting of representatives of the three parties oversee the project. Research is in progress at mines in Red Lake, Elliot Lake, Sudbury and Kirkland Lake.

Objective

To develop new seismic equipment and monitoring techniques for studying rockbursts in hardrock mines; to carry out seismic studies at mines in Sudbury, and other Ontario locations; to determine the causes and mechanisms of bursts and investigate methods for alleviation.

Summary of Achievements

Since the project started in 1985, a number of advances have been made in our knowledge and understanding of rockbursts and methods of alleviation. The highlights of these achievements are summarized below.

The use of microseismic systems to monitor seismic activity following a destress blast (or major production blast) has proved to be a very useful tool to determine the immediate stability of the area. It is possible to listen to seismic activity on surface prior to the labour force going underground.

Since 1984 rockbursts in Ontario mines have been classified by their magnitude. This has assisted in defining the extent of the problem, stability can be assessed over given time periods, and a comparison can be made between mines not only in Ontario but throughout the world. These magnitude values are obtained from the Eastern Canada Seismic Network, operated by Energy, Mines and Resources. At present, any rockburst of magnitude greater than 2.0 in Ontario mines is usually detected by this network. Installation of additional seismograph stations at Sudbury, Elliot Lake and Kirkland Lake will lower the threshold Limit of the recorded rockbursts.

After several years experience with microseismic monitoring systems, the Ontario mines have realized numerous benefits. Problem areas of a mine can be identified immediately from surface, and during an emergency the systems are invaluable. The pattern of microseismic activity frequently indicates the mechanisms of a rockburst. For instance, the fault-slip seismicity at Falconbridge, Strathcona and Garson mines was only realized after the microseismic systems indicated a concentration of microseismic events along geological structural planes.

The mining companies have made enormous progress in the graphical output from their microseismic systems. At many Ontario mines, company officials now have immediate access to plans and sections showing recent seismic activity in the areas they supervise.

Before developing methods to alleviate rockbursts, it is necessary to establish their causes and mechanisms. Three types have been identified; strains, pillar and fault-slip. All of these types have been observed in Ontario mines. The explosive energy liberated during a rockburst comes from the surrounding rock mass, rather than the structure that fails, (e.g. a pillar). The violence of the failure is controlled by the stiffness of the loading system (i.e., wall rocks). During rock failure the proportion of the released energy which is liberated seismically (i.e., seismic efficiency) varies with the different types of rockbursts. It is very low for fault-slip rockbursts and very high for pillar bursts.

Destress blasting is successfully used in Ontario mines to alleviate the rockburst problem or to control the time of its occurrence. In crown/sill pillars, in steeply-dipping orebodies, the purpose of the destress blast is to reduce the potential energy of the surrounding rock mass. This is achieved by fracturing the pillar and allowing the hanging wall and footwall to converge. One of the main criteria for a successful destress blast is the significant convergence that occurs.

The use of microseismic systems to monitor seismic activity following a destress blast (or a major production blast) has proved to be a very useful tool to determine the immediate stability of the area. It is possible to listen to seismic activity on surface prior to the labour force going underground.

RESPIRABLE DUST AND VENTILATION

Background

Dust control and ventilation are prerequisites of underground mining. It is necessary to dilute and remove the diverse pollutants that can become airborne in the mining environment. These pollutants may be either a health hazard on inhalation, a discomfort, or a nuisance.

Respirable dust is known to be the cause of lung ailments generally referred to as pneumoconiosis. Dust clouds are also a nuisance as they reduce visibility. Depending on the chemistry of the material mined and its host rock there can be added dangers, for example in uranium mines, inhaled dust can transport long-lived radionuclides into the respiratory system.

For both dust and ventilation research, improvements are continually being made to instrumentation and measurement techniques. These facilitate greater understanding of pollutant generation, pollutant properties, and eventually help to implement control strategies through suppression, filtration or ventilation techniques. Such information provides the basis for computer prediction and simulation programs that now form a necessary aid to the development of pollutant control measures.

Present dust research efforts centre on the characterization of dust generating operations, evaluation of control measures and provision of extensive calibration facilities for the diverse array of equipment employed. In ventilation research, the use of gas chromatography for air analysis and its associated use with tracer gases has greatly furthered the understanding of airflow characteristics, which in turn provide more information for the efficient control of pollutants. Similarly, new dust suppression techniques such as electrostatic precipitation and wet scrubbing are being evaluted in the mining environment.

Objective

The ultimate objective is to produce control strategies for airborne pollutants in order to reduce their concentration to acceptable levels. Interim objectives are the quantification and characterization of dust produced by various mining operations and also, to identify ventilation parameters that control the concentration of dust and to evaluate the efficiency and applicability of control techniques.

The evaluation of traditional and new control techniques is of paramount importance and a major portion of time and resources is dedicated to field work in that direction. Several types of dust filters and control techniques have been tested in underground hard rock mines. Specifically, self-induced wet dust collectors, electrically charged water sprays, and a combination fan/filter system for secondary ventilation applications have been evaluated in the field.

The wet dust collector evaluation was a major project. These units are not commonly used in Canadian hard-rock mines, and as such these tests have attracted a lot of interest from the mining industry and from agencies in the health and safety sector. Results of the field survey showed that the wet scrubbing system reduced airborne respirable dust concentrations by as much as 70% in some key areas. This study demonstrated that this air cleaning technology is worthy of consideration for dust control applications in underground mines.

Another study consisted of evaluating electrostatically charged water sprays. This project is one of the first to be successfully conducted under field conditions. Results have shown that under specific conditions of low ambient air velocity, two spray heads could succeed in reducing airborne respirable mineral dust by up to 35%.

Finally, a ventilation fan designed for low noise operation and to reduce dust emissions was tested in the field. The French designed fan is equipped with a fiber filter at the intake to protect the acoustic materials inside the unit. This filter is claimed by the manufacturer to reduce airborne dust and radiation concentrations at the exhaust. Results have shown that airborne contaminants were reduced by the filter to a certain extent. The efficiency of filtration, however, was lower than expected.

Continuous particulate monitoring instruments have been developed and tested in mining environments. Of these, the differentiating fiber/mineral and diesel soot/mineral monitors are still in the prototype stage, but a portable optical particle counter (OPC) was shown to be suitable for research investigations. The OPC provides real-time information on the size distribution of airborne particles. This is essential for the characterization of dust clouds and can provide information on time and space fluctuations of the distributions that were previously unavailable. Specific applications using the OPC have been the evaluation of water filtration systems for size dependent characteristics, and the characterization of a dust cloud size distribution produced from various crushing and material transport operations.

The dust test facility (DTF) installed at the Elliot Lake Laboratory has been evaluated and final fitting of all associated equipment is being completed. The DTF provides a calibration facility for dust and ventilation instruments under controlled conditions of airstream velocity and dust concentration that are comparable to those encountered in the mining environment. A method of measuring and controlling the size distribution of the calibration dust cloud is being investigated. The OPC allows the testing of dust instruments for any size selectivity in their sampling technique.

Specific improvements in ventilation research have been the upgrading of the Elliot Lake Laboratory tracer gas/gas chromatograph facilities. The present laboratory based chromatograph is being replaced with a portable unit that has real-time analysis capabilities to allow greater flexibility in its application and greater productivity in its usage.

The portable unit will provide an investigational tool to evaluate both mine and local ventilation systems and provide data on their efficiency. Tracer gas investigations provide pertinent data for the verification of computer models and information on the best deployment and usage of ventilation machinery.

Suggestions for Further Work

1. Maintain thrust in dust control studies while expanding data base on dust generation classification of mining operations. Primary studies will be oriented to field evaluation of specific dust suppression and control techniques.

2. Sustain calibration facilities or dust and ventilation instrumentation and evaluate any new developments.

3. Investigate the use of controlled recirculation as a ventilation technique. This system of ventilation has great potential for

reducing heating costs in Canadian mines as well as providing potentially better control and dilution rates of airborne contaminants.

4. Evaluate gravimetric dust samples used routinely by the mining industry as part of their safety and health progam. One example is the effect of electrostatic charge on samplers and on airborne dust on the efficiency of collection.

5. To characterize the amount of electric charge found on mine dust with the help of the newly built electrostatic elutriator. Knowledge of this parameter is of importance as the amount of charge on dust affects the efficiency of collection of some samplers.

6. To update the control unit on the X-ray apparatus used to determine the amount of airborne quartz from samples collected by gravimetric dust samplers.

RADIATION

Background

The radiation exposure to uranium mine personnel can be minimized by limiting the time of exposure, protecting the worker (e.g., shielding), and by reducing the radiation level. Mechanical (forced) ventilation is one effective way of reducing radiation levels at work sites. However, there are other methods that may prove to be both effective and economical in helping to control and/or minimize radiation levels. Such methods include: 1) coating mine walls with certain chemical sealants to reduce radon (thoron) migration through the walls; 2) use of mixing fans to eliminate decay products by plate-out on the fan blades and on wall surfaces by convective air currents set up by the fan; 3) use of DC electric fields to remove decay products by electrostatic precipitation; 4) use, in certain cases, of special 'loose' filter materials with electret properties to remove decay products by mechanical traping and electrostic precipitation.

Furthermore, reliable experimental radiation data depend very much on the adequate performance of measuring instrumentation. Hence, reliable instrumentation and proper testing calibration procedure of radiation instrumentation cannot be emphasized enough. In this light, the establishment of a large test facility for radon, thoron and their decay products is of great importance.

Finally, the International Commission on Radiological Protection (ICRP) has recently made recommendations regarding limits of exposure to long-lived radioactive dust in relation to total dose exposure to external gamma-radiation and airborne alpha-emitters (i.e., radon and thoron daughters in the submicron and respirable range). Hence, identification, characterization, and quantification of long-lived radioactive dust has become an important issue.

Objective

The objective is to identify major sources of radiation; to identify the major factors affecting the release of radiation; to develop control methods to reduce radiation levels to acceptable personal dose exposures, and to develop and test radiation instrumentation to carry out the above studies. Another objective is the establishment of a national test facility for radon, thoron and their decay products.

Achievements

New instruments (area monitors and personal dosimeters) suitable for continuous monitoring of radon and thoron gas, and their decay products, have been developed and technically evaluated under controlled laboratory conditions and under field conditions. The performance of these instruments has been very satisfactory. This instrumentation is compatible with commercially available data acquisition systems for telemetering data to surface for subsequent computer processing.

Field measurements were conducted on long-lived radioactive dust (LLRD) in the submicron and respirable ranges. The study was carried out at a crusher, and at a conveyor belt, in an Elliot Lake underground uranium mine. Further studies of LLRD were conducted after the installation of a wet scrubber in the same area to reduce and control dust emissions. The study showed that a substantial difference in size distribution and a dramatic reduction in LLRD concentration occurred after the installation of the wet scrubber. The above studies also showed significant differences in the size distribution and concentration of LLRD from the above operations when compared to the LLRD generated in other mining operations.

A comprehensive study on the characterization of LLRD in a uranium mill (Saskatchewan) has been completed. Size distribution and concentration studies were conducted for the major mechanical and physico-chemical operations of the mill.

Field tests of a charged water spray system were done in an underground uranium mine to investigate its effect on radiation levels, including long-lived radioactive dust. Data showed that under low ambient air flow conditions, a significant decrease in LLRD concentration was realized. The effect of the charged water spray on radon and thoron progeny concentration was rather more complex and not clearly understood.

Development of radiation/ventilation mine models suitable for steady-state and time-dependent conditions continued.

A radiation/ventilation study of bacterial leaching at Denison Mines has been completed. The results will be used to improve experimental operating conditions in the future. Tracer gas/gas chromatographic techniques were used to determine air residence times. A comparison between air residence time determined by purely radioactivity techniques developed at the Elliot Lake Laboratory and tracer gas methods was done with fairly good agreement.

A radiation/ventilation study at Stanleigh Mine has been completed. The data will be used to verify, among other things, radiation mine models and to estimate radiation data of practical interest. Air residence times were determined by tracer gas/gas chromatographic techniques and their values were applied to radiation mine models, developed at the Elliot Lake Laboratory, for verification purposes.

A study was carried out of a fan/filter ventilation system installed at Stanleigh Mine to investigate the effect of the system on airborne radioactive aerosols in the submicron and respirable ranges. The efficiency of the system in reducing the above contaminants was, however, rather low, i.e., 10%.

A special study (solicited by the Ministry of Labour of Newfoundland and Labrador) was conducted at the St. Lawrence Fluorspar Ltd. mine (Newfoundland) to characterize and quantify radiation sources at working sites, and other mine locations, under varying air flow conditions and mining operations. The results of this investigation are being analyzed.

Underground radiation and meteorological data collected by Denison Mines (under contract with AECB) during a one-year survey program has been analyzed by the radiation group of the Elliot Lake Laboratory. The aim of this study is to determine radon and thoron (gas and progenies) concentration and radon and thoron gas fluxes, and to use these data to verify or modify already existing radiation mine models and/or to develop new models best suitable for routine use by mining companies.

A radon/thoron test facility (RTTF) for simulation studies, testing and calibration of radiation instrumentation is being installed at the Elliot Lake Laboratory. This will be the National Test Facility for radon/thoron and their decay products and it is expected to begin operation on a trial basis some time in late 1988. The delay has been caused by problems with the bulding contractor in completing this facility.

Development of radiation/ventilation mine models suitable for steady-state and time-dependent conditions continued.

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Suggestions for Further Work

1. Close collaboration with respirable dust and ventilation scientists to characterize long-lived radioactive dust in uranium mines as related to mining operations, in particular, rock fragmentation.

2. Improvement of radiation/ventilation mine models for better assessment of radon and thoron daughter radiation levels for personal exposure determinations. Development of radiation/dust/ventilation mine models and field studies for better assessment of personal exposure levels, including exposure to long-lived radioactive dust.

3. Major thrusts in radiation control and suppression techniques including the contribution from rock fragmentation and rock handling to the radon/thoron level and long-lived radioactive dust concentrations. Major emphasis will be placed on built-in controls.

4. Calibration and technical evaluation of radiation instrumentation (area monitors and personal dosimeters) used for AECB compliance purposes by industry and from other users.

5. Development of radiation instrumentation for specific monitoring and control purposes, and interfacing of this instrumentation to a newly proposed Data Acquisition System/Automated Control System suitable for underground mine environments.

6. Further studies of the electrical characteristics of radioactive aerosols.

7. Use of air recirculation to investigate its effect on radiation levels at working locations. The study will be done using newly developed radiation sensors in conjunction with a newly acquired computer-based field portable gas chromatograph, which will be used for a twofold purpose, namely: determination of mine air residence times (using tracer gas), and the characterization and quantification of potential chemical indicators present in mine air.

MINE/MILL WASTE MANAGEMENT

Background

The environmental problems associated with managing mine/mill waste containing metal sulphides are well recognized. Upon weathering, many metal sulphides, such as pyrite, marcasite and pyrrhotite in tailings oxidize in the presence of moisture, oxygen and iron-oxidizing bacteria-thiobacilli ferro-oxidans. The oxidation produces acidic conditions within the tailings which subsequently leach many residual metals (and trace radionuclides in uranium tailings) from the tailings material resulting in highly acidic, high total dissolved solids, tailings porewater.

With precipitation and recharge events, these oxidation reaction products can migrate from the tailings with surface run-off and as subsurface seepage to the surrounding environment, thereby affecting the natural quality of the area water system if control methods are not used. To control wind and water erosion, many inactive tailings sites have been successfully stabilized by revegetation which has greatly improved the aesthetics, and to a certain extent, the amount of water percolating through, because of increased evapotranspiration. The overall impact of revegetation on the quality and quantity of effluent from reclaimed tailings area has yet to be determined. Other tailings management options such as dry and wet covers, in situ consolidation of tailings and down stream passive treatment are to be evaluated for their long-term physical and chemical stability and effectiveness in minimizing acid generation potential.

Objective

The objective is to develop an effective technology of tailings disposal and management which will enable the mining industry to abandon mine/mill waste in a predictable, cost effective and environmentally acceptable manner.

Achievements

Under the Reactive Tailings (RATS) program, hydrogeochemical investigations of a reactive sulphide tailings basin are being carried out at the Waite Amulet tailings site in Noranda, Québec. The study included measurements of solid phase physical, chemical and mineralogical parameters, liquid phase porewater geochemistry of unsaturated and saturated zones, and unsaturated zone pore-gas composition.

The results showed that the unsaturated zone porewater had a pH generally less than 3 with elevated metal levels. Pyrrhotite and pyrite were strongly oxidized in the near-surface zone and exhibited decreases to negligible alteration with depth. The saturated zone water has a pH generally greater than 5 with significantly lower dissolved metal levels. The mineralogy in the saturated zone indicated minimal to no signs of pyrrhotite and pyrite alteration.

The pore gas oxygen concentrations in the unsaturated zone indicated that O_2 was present generally to depths less than 1m. This is consistent with the oxidation profile, and gaseous O_2 availability may control oxidation. Consolidation and strength characteristics of pyritic uranium tailings stabilized with lime, carbon dioxide and blast furnace slag cement were measured for backfill and in situ consolidation applications. The ultimate compressive strengths for tailings/lime stabilization were comparable to that of tailings/cement with no noticeable effect from the carbon dioxide mixing environment. The highest compressive strength and modulus of elasticity were obtained for blast furnace slag cement where the presence of aluminum oxide and silica provided additional binding and strength with the formation of hydrated alumino silicates.

The geochemistry of a thickened tailings pile at the Denison tailings site in Elliot Lake was evaluated to determine its chemical stability. The results have shown that the pile has been completely oxidized with the unsaturated zone pH ranging between 2-3 with elevated metal and sulphate levels.

The revegetation potential of a previously reclaimed and flood damaged section of the Nordic tailings site in Elliot Lake was evaluated for volunteer vegetation growth. About 50% of the damaged area has a vegetation cover with a bio-yield of 30% compared to that of the undamaged vegetated section.

Suggestions for Further Work

Collaborative work between the Elliot Lake Laboratory and participating RATS industry members such as Noranda, INCO, Falconbridge and Cominco will be continued. Major areas of future research will be in the direction of predictive modelling and cover technology.

With the cooperation of Denison and Rio Algom mines in Elliot Lake, studies on the thickened tailings pile and future close-out options will be continued.

In cooperation with Laurentian University, Sudbury, migration of radionuclides from uranium tailings via various environmental pathways will also be pursued.

MINING RESEARCH LABORATORIES
1987
Reports Listing for Elliot Lake

CANMET SPECIAL PUBLICATIONS

SP 87-2	Rockbursts in Ontario Mines During 1985	D. Hedley
SP 87-7 E	1986-1987 Annual Report of the Canada-Ontario-Industry Rockburst Project	C.H. Brehaut D.G.F. Hedley
SP 87-7 F	Rapport annuel 1986-1987 du projet de recherche conjoint Canada-Ontario-Industrie sur les coups de toit	C.H. Brehaut D.G.F. Hedley
SP 87-8 E	Destress blasting at Campbell Red Lake Mine	A. Makuch M. Neumann D.G.F. Hedley W. Blake
SP 86-14 F	Conception d'un nouveau système de surveillance macrosismique	A. Makuch
SP 86-15 F	Techniques de localisation des foyers fondées sur l'arrivée des ondes P	J. Niewiadomski

JOINT PANEL REPORT

	1986 Annual Report for the Joint Panel on Occupational and Environmental Research for Uranium Production in Canada	R. Tervo

MRL PUBLICATIONS

87-09(OP)	Progress during the second half of 1986 in the Environment projects of the CANMET Minerals Program	J. Bigu
87-12(TR)	High resolution alpha-spectrometry for radium analysis - The effects of sample thickness and filter pore size	T.P. Lim N.K. Davé N.R. Cloutier
87-15(TR)	Field stress determination at the Niobec Mine, Chicoutimi, Quebec	B. Arjang
87-16(OP)	Wet dust collectors as a means of mineral dust control	M. Grenier
87-17(J)	A reference size-selective sampler for respirable dust	G. Knight
87-19(OP)	A preview of the national radon/thoron test facility	J. Bigu
87-21(TR)	Review of rockburst incidents at the Macassa Mine Kirkland Lake	B. Arjang G. Nemcsok

87-27(INT)	Annual Review - Elliot Lake Laboratory	R. Tervo
87-36(TR)	Calibration of the NFOLD displacement discontinuity model of "A" zone at Campbell Red Lake Mine	D. Hanson
87-41(OPJ)	Applying tracer gas techniques to evaluate air distribution in flood leaching stopes	S. Hardcastle A. Sheikh
87-42(TR)	Results of a long-term personal dosimetry program at Rio Algom Ltd. (Stanleigh Mine)	J. Bigu B. Palmer I. Montgomery
87-49(TR)	Results of a long-term personal dosimetry program at Rio Algom (Quirke) Mines	J. Bigu B. Palmer I. Montgomery
87-50(LS)	Catalogue of rockburst literature	D.G.F. Hedley
87-51(OP)	Evaluation of a water type dust collector at an underground crushing operation	M. Grenier S. Hardcastle J. Bigu
87-58(IR)	Dust production at an ore and waste dump area in an underground uranium mine	G. Knight
87-60(J)	Conversion factors for calculating working levels using continuous radon progeny time-integrating monitors	J. Bigu
87-61(J)	Effect of selected variables on airborne 220 RN progeny concentrations	J. Bigu
87-62(TR)	222RN and 220RN progeny relationship in Canadian underground uranium mines	J. Bigu
87-64(TR)	Characterization of long-lived radioactive dust emissions in physico-chemical operations in a uranium mill	J. Bigu E. Edwardson
87-65(TR)	Characterization of long-lived radioactive dust clouds generated in mechanical operations in a uranium mill	J. Bigu E. Edwardson
87-66(OP)	The Canada-Ontario-Industry Rockburst Project	D. Hedley J. Udd
87-67(J)	Long-lived radionuclides in quartz dust samples from hard rock uranium mines	J. Bigu
87-68(TR)	Evaluation of the climate and air flow in a flood leaching stope	S. Hardcastle K.C. Butler

87-69(OP)	Source location techniques for seismic activity in mines	J. Niewiadomski
87-75(OPJ)	Evaluation of the air quality and distribution during the rest period of bacterial flood leaching operations in uranium mines	S. Hardcastle A. Sheikh
87-78(OPJ)	The effect of time-dependent ventilation and radon (thoron) gas emanation rates in underground uranium mines	J. Bigu
87-82(TR)	Destressing a rockburst prone crown pillar - Macassa Mine	D. Hanson W. Quesnel R. Hong
87-83(OP)	Progress during the first half of 1987 in the environment projects of the CANMET Minerals Program	J. Bigu
87-84(OPJ)	Effects of various tailing covers on radon gas emanation from pyritic uranium tailings	N. Dave T.P. Lim
87-85(TR)	Performance of a wet scrubber to reduce long-lived radioactive dust emissions in underground uranium mines	J. Bigu M. Grenier S. Hardcastle
87-93(TR)	Consolidation strength characteristics of pyritic uranium tailings using: 1) powdered nd hydrated lime in carbon 2) slag cement	N. Dave T.P. Lim J. Chakravatti
87-95(TR)	Efficiency tests on a wet dust collector in a hard rock mine	G. Knight S. Hardcastle
87-101(J)	Reduction of airborne radioactive dust by means of a charged water spray	J. Bigu M. Grenier
87-105(TR)	Characterization of long-lived radioactive dust clouds generated in uranium mill operations	J. Bigu P. Duport
87-106(TR)	The use of tailings as backfill in underground uranium mines	J. Bigu
87-108(TR)	Review and evaluation of ground stresses at Campbell Red Lake Mine, Ontario	B. Arjang
87-109(TR)	Underground evaluation of a fan/filter system for dust reduction capabilities	M. Grenier J. Bigu
87-110(TR)	Technical evaluation of a radon progeny instant working level meter in an underground uranium mine	J. Bigu

87-111(TR)	Evaluation of a fan/filter system to reduce radon (and thoron) progeny in underground uranium mines	J. Bigu M. Grenier
87-112(TR)	Airflow determination for radiation emanation investigations of a large worked out area of uranium mine	S. Hardcastle J. Bigu
87-117(TR)	Laboratory and field evaluation of new radon progeny working level monitor using low-power CMOS electronics	J. Bigu
87-118(TR)	Rockburst mechanics	D. Hedley
87-119(J)	Characterization of airborne dust in a belt Conveyor drift - Revision of MRL 86-51(OP)	M. Grenier S. Hardcastle J. Bigu
87-134(OP)	Progress during the second half of 1987 in the environment projects of the CANMET Mineral's Program	J. Bigu
87-142(TR)	Field stresses at the Kidd Creek Mine, Timmins, Ontario	B. Arjang
87-143(OPJ)	Systèmes d'information et de communication dans les mines souterraines canadiennes	R. Tervo N. Billette
87-144(TR)	X-ray diffraction analysis of mine airborne dust - An interference problem at Helmo Gold Mine	G. Knight W. Zawadski
87-147(TR)	Ground stresses at La Mine Bousquet, Quebec	B. Arjang
87-155(J)	Suppression of airborne dust in hardrock mines by means of electrostatic water sprays	M. Grenier J. Bigu
87-156(TR)	Magnitude scaling of seismic events at Elliot Lake	P. Rochon D.G.F. Hedley
87-160(OP) E	Rockbursts	D.G.F. Hedley
87-160(OP) F	Coups de Toit	D.G.F. Hedley P. Rochon
87-165(OP) E	Underground mining methods, planning and ground control	D.G.F. Hedley
87-165(OP) F	Méthodes d'exploitation souterraines, planification et contrôle des terrains	D.G.F. Hedley Traduit par P. Rochon

87-167(OP)	A portable computer controlled multi-size range aerosol counting system for use in underground mining environments	S.G. Hardcastle J. Cavan
87-172(OPJ)E	Control of radiation and dust in underground mines (See 87-182(OPJ) F)	J. Bigu M. Grenier
87-173(IR)	Rapid XRD Analysis of quartz in airborne dust samples using computer control Revision of MRL 80-101(OPJ)	G. Knight
87-174(TR)	Radioactivity emissions from bacterially-assisted leaching of uranium stopes	J. Bigu D. Schryer
87-180(TR)	Radiation levels in backfilled areas at Denison Mines Ltd.	J. Bigu M. Grenier A. Frattini
87-182(OPJ)F	Évaluation des sources et des niveaux de poussière et taux de radiation dans les mines. Stratégies de contrôle (Voir 87-172(OPJ)E)	M.G. Grenier J. Bigu
87-184(TR)	Initial trials of a proposed particle counter for underground use	S. Hardcastle J. Cavan
87-186(INT)	Annual Review - Elliot Lake Laboratory	R. Tervo
87-187(TR)	Evaluation of a split flow elutriator used in the determinations of airborne dust charged distributions	M. Grenier K. Butler

APPENDIX A

Publications

MINING RESEARCH LABORATORIES
1987
Reports Listing

CANMET SPECIAL PUBLICATIONS

SP 87-2	Rockbursts in Ontario Mines During 1985	D. Hedley
SP 87-3	Sulphide dust explosion Proceedings of a workshop sponsored by Noranda Minerals Inc., GECO Division at Manitouwadge, Ontario, October 23 and 24, 1986)	E.D. Dainty L.B. Geller
SP 87-5	Index of Mining Technology Projects 1987 Répertoire de Projets en Technologie Minière 1987	N. Billette P. Lacourse
SP 87-7 E	1986-1987 Annual Report of the Canada-Ontario-Industry Rockburst Project	C.H. Brehaut D.G.F. Hedley
SP 87-7 F	Rapport annuel 1986-1987 du projet de recherche conjoint Canada-Ontario-Industrie sur les coups de toit	C.H. Brehaut D.G.F. Hedley
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JOINT PANEL REPORT

	1986 Annual Report for the Joint Panel on Occupational and Environmental Research for Uranium Production in Canada	R. Tervo

JOURNAL SUBMISSIONS (J)

87-17(J)	A reference size-selective sampler for respirable dust	G. Knight
87-60(J)	Conversion factors for calculating working levels using continuous radon progeny time-integrating monitors	J. Bigu

87-61(J)	Effect of selected variables on airborne 220 RN progeny concentrations	J. Bigu
87-67(J)	Long-lived radionuclides in quartz dust samples from hard rock uranium mines	J. Bigu
87-76(J)	Kinetic studies of the thermal decomposition of nitroguanidine using accelerated rate calorimetry	P. Lee M. Back
87-101(J)	Reduction of airborne radioactive dust by means of a charged water spray	J. Bigu M. Grenier
87-114(J)	La recherche minière à CANMET: Impact des ententes fédérales-provinciales	J. Udd A. Boyer N. Billette
87-119(J)	Characterization of airborne dust in a belt conveyor drift - Revision of MRL 86-51(OP)	M. Grenier S. Hardcastle J. Bigu
87-155(J)	Suppression of airborne dust in hardrock mines by means of electrostatic water sprays	M. Grenier J. Bigu

ORAL PRESENTATIONS (OP)

87-09(OP)	Progress during the second half of 1986 in the environment projects of the CANMET minerals program	J. Bigu
87-10(OP) E	Summary of 24 surface crown pillar case studies	M. Bétournay S. Nantel D. Lessard
87-10(OP) F	Sommaire de 24 histoires de cas de piliers de surface	M. Bétournay S. Nantel D. Lessard
87-16(OP)	Wet dust collectors as a means of mineral dust control	M. Grenier
87-19(OP)	A preview of the national radon/thoron test facility	J. Bigu
87-26(OP)	Testing of fire-resistance of materials used in canadian mines	K. Mintz
87-28(OP)	Process control in hazardous locations	J. Bossert
87-34(OP)	Applied rock mechanics research at CANMET - projects in progress through Fed/Prov MDA agreements	J.E. Udd

87-37(OP)	Influence of various parameters on underground accidents: A multi-factorial approach in Quebec mines	N. Billette M. Laflamme
87-40(OP)	Equipment development trends: CANMET past and present involvements	N.R. Billette
87-44(OP)	Continuing education needs survey results	N. Billette J. Udd
87-51(OP)	Evaluation of a water type dust collector at an underground crushing operation	M. Grenier S. Hardcastle J. Bigu
87-53(OP)	Summary reports of progress on tri-partite USBM/MOL/CANMET Research Projects 86/87	J.E. Udd E.D. Dainty L. Geller
87-55(OP)	Communication systems for isolated areas in mines Phase II	S. Soneff S. Vongpaisal
87-57(OP)	La recherche minière à CANMET: Impact des ententes fédérales-provinciales	J. Udd N. Billette A. Boyer
87-63(OP)	Impact of various parameters on underground accidents in Quebec mines: A multifactorial approach	N.R. Billette M. Laflamme
87-66(OP)	The Canada-Ontario-Industry Rockburst Project	D. Hedley J. Udd
87-69(OP)	Source location techniques for seismic activity in mines	J. Niewiadomski
87-70(OP)	Suivi géotechnique du fonçage par tunnelier à la mine Donkin-Morien, en Nouvelle-Écosse	J.L. Gilby C.M.K. Yuen T.R.C. Aston
87-77(OP)	A study into the thermal decomposition kinetics of nitroguanidine using accelerated rate calorimetry	P. Lee M. Back
87-83(OP)	Progress during the first half of 1987 in the environment projects of the CANMET Minerals Program	J. Bigu
87-92(OPJ)	Coring of Soft Soil-Like Rock Materials	M.C. Bétournay C. Mirza K.C. Lau
87-100(OP)	Capabilities, limitations and the use of the Georoc computer package	Y. Yu
87-115(OP)	Small mines: the importance to Canada's mining industry, the characteristics, the problems, and the needs for technology	J.E. Udd N.R. Billette R.W.D. Clarke

87-130(OP)	Fundamental information for TIGER code calculations (2) determination of potential energy function parameters	D. Jones R. Triebe
87-131(OP) E	Applied research projects in progress at the Mining Research Laboratories of CANMET	J.E. Udd
87-131(OP) F	Recherche appliquée - Projets en cours aux laboratoires de recherche minière du CANMET	J.E. Udd
87-132(OP) E	The work of the Mining Research Laboratories Division of CANMET	J.E. Udd
87-132(OP) F	Les travaux de la division des laboratoires de recherche minière du CANMET	J.E. Udd
87-133(OP)	Improvement of diesel engine performance from the standpoint of gas and soot emissions reduction	D. Dainty
87-134(OP)	Progress during the second half of 1987 in the environment projects of the CANMET Minerals Program	J. Bigu
87-135(OP) E	Exploitation in small mines - An outside view presentation	J. Pathak J. Udd
87-135(OP) F	L'exploitation des petites mines souterraines; vues de l'extérieur	J. Pathak J. Udd
87-136(OP)	Diamond drilling of rigid soils and altered rock materials	M. Bétournay
87-154(OP)	L'instrumentation dédiée au contrôle des terrains	G. Herget M. Bétournay
87-160(OP) E	Rockbursts	D.G.F. Hedley
87-160(OP) F	Coups de toit	D.G.F. Hedley P. Rochon
87-165(OP) E	Underground mining methods, planning and ground control	D.G.F. Hedley
87-165(OP) F	Méthodes d'exploitation souterraines, planification et contrôle des terrains	D.G.F. Hedley P. Rochon
87-167(OP)	A portable computer controlled multi-size range aerosol counting system for use in underground mining environments	S.G. Hardcastle J. Cavan

ORAL PRESENTATIONS AND JOURNAL SUBMISSIONS (OPJ)

87-01(OPJ)	Rockburst research in Canada - 1987	J. Udd D. Hedley
87-07(OPJ)	Computer simulation of a room-and-pillar mining system in a Canadian potash mine	Y. Yu C.G. Ong P. Mottahed
87-14(OPJ)	A case study of surface crown pillars: The Niobec Mine	M. Bétournay Y. Yu
87-18(OPJ)	Tests of a prototype Venturi scrubber system	P. Mogan D. Dainty
87-22(OPJ)	Impact de variables quantitatives sur les accidents en souterrain: Analyse multifactorielle	N. Billette M. Laflamme R.J. Keyes L. Marcoux
87-23(OPJ)	Recherche sur les liens entre boni et accidents: Etude préliminaire	N. Billette J.L. Chouinard
87-32(OPJ)	CANMET's role in mine equipment development	N. Billette
87-39(OPJ)	Éléments géomécaniques de récupération de piliers de surface	M. Bétournay
87-41(OPJ)	Applying tracer gas techniques to evaluate the air distribution in flood leaching stopes	S. Hardcastle A. Sheikh
87-46(OPJ)	Mining in the 21st Century	J. Pathak
87-75(OPJ)	Evaluation of the air quality and distribution during the rest period of bacterial flood leaching operations in uranium mines	S. Hardcastle A. Sheikh
87-78(OPJ)	The effect of time-dependent ventilation and radon (thoron) gas emanation rates in underground uranium mines	J. Bigu
87-84(OPJ)	Effects of various tailing covers on radon gas emanation from pyritic uranium tailings	N. Dave T.P. Lim
87-86(OPJ)	Mine environment monitoring system and sensor performance evaluations	M. Gangal E.D. Dainty
87-92(OPJ)	Coring of Soft Soil-Like Rock Materials	M.C. Bétournay C. Mirza K.C. Lau
87-125(OPJ)	Status of in mine diesel particulate filter trials	F. Enga D. Dainty

87-126(OPJ)	Orebodies and mine planning 3-D modelling, Phase I: Geological contours and ore reserves assessment	A. Boyer N. Billette R. Boyle
87-143(OPJ)	Systèmes d'information et de communication dans les mines souterraines canadiennes	R. Tervo N. Billette
87-146(OPJ)	Les logiciels des LRM pour les mines souterraines	R. Boyle A. Boyer
87-172(OPJ) E	Control of radiation and dust in underground mines	J. Bigu M. Grenier
87-181(OPJ)	Mutagen levels in the treated and untreated exhaust of diesel engines in common use in underground mining	J.P. Mogan E.D. Dainty K.C. Westaway A.J. Horton
87-182(OPJ)	Evaluation des sources et des niveaux de poussière et taux de radiation dans les mines. Stratégies de contrôle	M.G. Grenier J. Bigu
87-190(OPJ) F	Les petites mines souterraines vues de l'extérieur: Politiques et contribution de CANMET	J.E. Udd N.R. Billette
87-191(OPJ) E	Certification of fire-resistant materials for use in underground mines	J.A. Bossert
87-191(OPJ) F	Certification des matériaux résistant au utilisés dans les mines souterraines	J.A. Bossert

TECHNICAL REPORTS (TR)

87-03(TR)	Laboratory confirmation of methods of respirable combustible dust determination	D. Dainty J. Ebersole J. Vallières M. Gangal
87-04(TR)	Post-failure multi-stage triaxial strength determinations using a computer controlled servo-hydraulic test system	B. Gorski
87-06(TR)	Monitoring of borehole deformation of the Niobec Mine - A progress report	G. Herget F. Kapeller
87-08(TR)	A user-manual of the CDDE/1.0 computer program - optimization of drill log data entry into a computer data bank	A. Boyer R. Boyle
87-12(TR)	High resolution alpha-spectrometry for radium analysis - The effects of sample thickness and filter pore size	T.P. Lim N.K. Davé N.R. Cloutier

87-15(TR)	Field stress determinations at the Niobec Mine, Chicoutimi, Quebec	B. Arjang
87-20(TR) E	MRL Annual Report	D. Hill
87-20(TR) F	Rapport Annuel LRM	D. Hill
87-21(TR)	Review of rockburst incidents at the Macassa Mine Kirkland Lake	B. Arjang G. Nemcsok
87-24(TR)	The microseismic monitoring system at the Camborne School of Mines, geothermal energy project, Rosemanowes Quarry, Cornwall, U.K.	J.E. Udd
87-25(TR)	IMPRESSLIB Fortran impress interface library	N. Toews A.S. Wong
87-29(TR)	Index testing of fractures in URL diamond drill cores (Level II concept assessment draft report)	A. Annor R. Jackson
87-31(TR)	Results of direct shear tests on small block cold spring quarry specimens	R. Jackson A. Annor
87-35(TR)	Studies into thermal stability and reactivity ammonium nitrate Part 3. Characterization of ammonium nitrate and metal reaction products	P. Lee R. Snippe R. Vandebeek
87-36(TR)	Calibration of the NFOLD displacement discontinuity model of the "A" zone at Campbell Red Lake Mine	D. Hanson
87-42(TR)	Results of a long-term personal dosimetry program at Rio Algom Ltd. (Stanleigh Mine)	J. Bigu B. Palmer I. Montgomery
87-45(TR) E&F	English-French lexicon of surface crown pillar related terms/Lexique français-anglais de la terminologie reliée aux piliers de surface	M. Bétournay
87-48(TR)	International index of Mining Technology Projects	R.J. Welwood
87-49(TR)	Results of a long-term personal dosimetry program at Rio Algom (Quirke) Mines	J. Bigu B. Palmer I. Montgomery
87-56(TR) E	Mining Research Projects (except for coal) 1987-88	D.M. Hill

87-56(TR) F	Projets de Recherche Minière (autres que le charbon) 1987-88	D.M. Hill
87-59(TR)	The removal of cones from tri-cone drill bits using explosives	D.L. Cox D.L. Wilson
87-62(TR)	222RN and 220RN progeny relationship in Canadian underground uranium mines	J. Bigu
87-64(TR)	Characterization of long-lived radioactive dust emissions in physico-chemical operations in a uranium mill	J. Bigu E. Edwardson
87-65(TR)	Characterization of long-lived radioactive dust clouds generated in mechanical operations in a uranium mill	J. Bigu E. Edwardson
87-68(TR)	Evaluation of the climate and airflow in a flood leaching stope	S. Hardcastle K.C. Butler
87-71(TR)	Flame tests for flexible ventilation materials and mine brattice cloth-operating procedures	N. Sarin
87-72(TR)	Burning trial on schedule IV container	E. Contestabile R. Vandebeek R. Augsten
87-74(TR)	Operating procedures - Flame tests on rigid ducts used for mine ventilation	N.K. Sarin
87-80(TR)	Post-failure uniaxial testing on URL1 core	R. Jackson
87-81(TR)	6th ISRM congress promotion and S. American lecture tour	G. Herget
87-82(TR)	Destressing a rockburst prone crown pillar - Macassa Mine	D. Hanson W. Quesnel R. Hong
87-85(TR)	Performance of a wet scrubber to reduce long-lived radioactive dust emissions in underground uranium mines	J. Bigu M. Grenier S. Hardcastle
87-87(TR)	An overview of developments in rock mechanics in Canada 1983-1987	J.E. Udd
87-89(TR)	The CEAL Propane Gallery Test	K. Mintz
87-90(TR)	Preliminary geomechanical assessment of the Dumagami Mine	M. Bétournay

87-91(TR)	Preliminary geomechanical assessment of the Eldrich-Flavel Mine	M. Bétournay
87-93(TR)	Consolidation strength characteristics of pyritic uranium tailings using: 1) powdered and hydrated lime in a carbon dioxide environment, and 2) slag cement	N. Dave T.P. Lim J. Chakravatti
87-95(TR)	Efficiency tests on a wet dust collector in a hard rock mine	G. Knight S. Hardcastle
87-96(TR)	Stability assessment of S-L-102-17 sill pillar of the Niobec Mine, Chicoutimi, Québec - Part III	Y. Yu A.S. Wong S. Vongpaisal N. Toews
87-104(TR)	Anisotropic properties study of Lac du Bonnet granite specimens: Report No. 4	R. Jackson
87-105(TR)	Characterization of long-lived radioactive dust clouds generated in uranium mill operations	J. Bigu P. Duport
87-106(TR)	The use of tailings as backfill in underground uranium mines	J. Bigu
87-107(TR)	Computer blast design programs for underground stopes (user manual for programs VCRM, LDBB, and PGRAPH	P. Lacourse R. Boyle
87-108(TR)	Review and evaluation of ground stresses at Campbell Red Lake Mine, Ontario	B. Arjang
87-109(TR)	Underground evaluation of a fan/filter system for dust reduction capabilities	M. Grenier J. Bigu
87-110(TR)	Technical evaluation of a radon progeny instant working level meter in an underground uranium mine	J. Bigu
87-111(TR)	Evaluation of a fan/filter system to reduce radon (and thoron) progeny in underground uranium mines	J. Bigu M. Grenier
87-112(TR)	Airflow determination for radiation emanation investigations of a large worked-out area of a uranium mine	S. Hardcastle J. Bigu

87-117(TR)	Laboratory and field evaluation of a new radon progeny working level monitor using low-power CMOS electronics	J. Bigu
87-118(TR)	Rockburst mechanics	D. Hedley
87-124(TR)	Instrumentation of Hartmann & 20L dust explosibility tests at CEAL	K. Judge
87-128(TR)	Results of parametric studies performed for the development of support design guidelines	M. Gyenge
87-137(TR)	Evaluation of support systems for weak rock masses	M. Bétournay
87-138(TR)	Dust explosibility tests: Hartmann apparatus	K. Mintz
87-139(TR)	Derivation of the brake specific ventilation equation and an operating load factor expression relevant to the use of diesel machinery underground	D. Dainty
87-142(TR)	Field stresses at the Kidd Creek Mine, Timmins, Ontario	B. Arjang
87-144(TR)	X-ray diffraction analysis of mine airborne dust - An interference problem at Helmo Gold Mines	G. Knight W. Zawadski
87-145(TR) E	Overview of Mining Research Laboratories Activities	A. Boyer P. Lacourse
87-145(TR) F	Tour d'horizon des activités des laboratoires de recherche minière (narration du film vidéo)	A. Boyer P. Lacourse
87-147(TR)	Ground stresses at La Mine Bousquet, Quebec	B. Arjang
87-156(TR)	Magnitude scaling of seismic events at Elliot Lake	P. Rochon D.G.F. Hedley
87-157(TR)	Derivation of the ventilation recirculation equations relevant to underground dieselized machines	E.D. Dainty
87-158(TR)	Uniaxial mechanical and dynamic properties of anomolous rock samples from Lac du Bonnet, Manitoba: Report #1	R. Jackson
87-159(TR)	Artificial support (including backfill)	A. Annor R.W.D. Clarke P. Lacourse

87-162(TR)	Interface for 12-bit Squirrel Data Logger to read vibrating wire sensors	F. Kapeller
87-163(TR)	Pocket size frequency counter for reading vibrating wire strain rings and vibrating wire exciter units	F. Kapeller
87-169(TR)	Strength determinations of Montauban Mine rocks	B. Gorski M. Little M. Bétournay
87-170(TR)	Published underground environment dust reports CANMET/Mining Research Laboratories 1960-1987	G. Knight
87-174(TR)	Radioactivity emissions from bacterially assisted leaching of uranium stopes	J. Bigu D. Schryer
87-176(TR)	The characterization of the Montauban Mine rock mass	M. Bétournay
87-178(TR)	Environmental law and its impact on the CANMET conveyor belt test facility	G. Lobay
87-180(TR)	Radiation levels in backfilled areas at Denison Mines Ltd.	J. Bigu M. Grenier A. Frattini
87-184(TR)	Initial trials of a proposed particle counter for underground use	S. Hardcastle J. Cavan
87-185(TR)	Instrumentation for ground control	G. Herget
87-187(TR)	Evaluation of a split flow elutriator used in the determination of airborne dust charged distributions	M. Grenier K. Butler
87-188(TR)	Comparison of Montauban rock types with various strength tests	M. Bétournay
87-189(TR)	Tensile strength of Montauban mine rocks	M. Bétournay

INTERNAL REPORTS (INT)

87-05(INT)	Visites de mines 1986 mine site visits	R. Clarke P. Lacourse
87-27(INT)	Annual review - Elliot Lake laboratory	R. Tervo
87-33(INT)	Post-failure uniaxial strength determinations using a servo-hydraulic test system	B. Gorski

87-38(INT)	Canada/New Brunswick mineral development agreement, Task II.14: Evaluation of improved methods for the non-destructive testing of mine-shaft wire-ropes - A project proposal	L. Geller J. Udd
87-43(INT)	Visit to Japan, Feb. 9-27, 1987	K. Mintz
87-47(INT)	Frictional properties established by confined shear test method	M. Gyenge
87-52(INT)	Nuclear fuel waste management program concept assessment document - Geotechnical studies at Whiteshell Research Area (RA-3). Rock properties, March 2, 1987	Edited by: T.J. Katsube J.P. Hume
87-54(INT)	Documentation of TEKPS	N. Toews A.S. Wong
87-94(INT)	Geotechnical studies at East Bull Lake research area (RA-7)	Edited by: A.G. Latham
87-116(INT)	Modal analysis of a pinkish granitic rock sample from Cold Spring Quarry, near Pinawa, Manitoba	A.S. Wong
87-120(INT)	PSPRINT Postscript laser print utility	N. Toews A.S. Wong
87-129(INT)	Instrumentation program at Swiss Institute of Technology and Grimsel Test Site	G. Herget
87-140(INT)	Rapport des visites du mines du sud-est de la Colombie Britannique dans le cadre de la collecte d'informations pour le répertoire de projets en technologie minière	N. Billette R. Rouleau
87-168(INT)	Documentation of TEKPS	N. Toews A.S. Wong
87-183(INT)	Répertoire de projets en technologie minière. Guide de l'usager	P. Lacourse
87-186(INT)	Annual review - Elliot Lake laboratory	R. Tervo

INVESTIGATION REPORTS (IR)

87-58(IR)	Dust production at an ore and waste dump area in an underground uranium mine	G. Knight
87-97(IR)	Review of cutting technology for evaporite mining	G. Knight

87-98(IR)	Proposal for development of cutting technology for evaporite mining	G. Knight
87-99(IR)	Proposal for dust generation and engineering parameter study in rock loading	G. Knight J. Pathak
87-103(IR)	Review of dust control and engineering parameters in loading	G. Knight
87-148(IR)	Review of cutting technology for evaporite mining	G. Knight
87-149(IR)	Proposal for development of cutting technology for evaporite mining: Part 1: review of mining company in-house research	G. Knight
87-150(IR)	Proposal for dust generation and engineering parameter study in rock loading	G. Knight J. Pathak
87-151(IR)	Review of dust control and engineering parameters in loading	G. Knight J. Pathak
87-152(IR)	Proposal for wetting ore standing in stopes	G. Knight
87-153(IR)	Proposal for tests of wetting agents for dust suppression on sulphide ores	G. Knight
87-173(IR)	Rapid XRD analysis of quartz in airborne dust samples using computer control (Revision of MRL 80-101 (OPJ))	G. Knight

LITERATURE SEARCH (LS)

87-50(LS)	Catalogue of rockburst literature	D.G.F. Hedley

RESEARCH REPORTS (R)

87-179(R)	Quartz analysis x-ray diffraction with computer control-computer programs and explanations	G. Knight

CONFIDENTIAL REPORTS (CF)

Twenty confidential reports were completed by MRL in FY 87/88.

PRESENTATIONS

Bétournay, M.C., Nantel, S. and Lessard, D. "Summary of 24 surface crown pillar case studies"; presented at the 89th Annual General Meeting of the Canadian Institute of Mining and Metallurgy, Toronto, Ontario, May 3-6, 1987. [DIVISIONAL REPORT MRL 87-10 E]

Bétournay, M.C., Nantel, S. and Lessard, D. "Sommaire de 24 histoires decas de piliers de surface"; présentation, 89ième Réunion Annuelle de l'Institut canadien des mines et de la métallurgie, Toronto, le 3-7 mai, 1987. [DIVISIONAL REPORT MRL 87-10-F]

Bétournay, M.C., Yu, Y.S. and Thivierge, S. "A case study of surface crown pillars: The Niobec Mine" presented at the 28th U.S. Rock Mechanics Symp., Tucson, Arizona, June 29-July 1, 1987. [DIVISIONAL REPORT MRL 87-14]

Bétournay, M.C. "Éléments géomécaniques de récupération de piliers de surface"; présentation, 31ème colloque sur le contrôle de terrain, Association des Mines de Métaux du Québec, Val d'Or le 8 avril 1987. [DIVISIONAL REPORT MRL 87-39]

Bétournay, M.C. "Diamond drilling of rigid soils and altered rock materials"; presented to the Ottawa Section of the Canadian Geotechnical Society, December 8, 1987. [DIVISIONAL REPORT MRL 87-136]

Bigu, J. "Progress during the second half of 1986 in the environment projects of CANMET's Mineral Program"; presented to the Joint Panel on Occupational and Environmental Research for Uranium Production in Canada, Hull, Quebec, Nov. 25-26, 1986. [DIVISIONAL REPORT MRL 87-9]

Bigu, J. "A preview of the National Radon/Thoron Test Facility"; presented to the Joint Panel on Occupational and Environmental Research for Uranium Production in Canada, Hull, Quebec, Nov. 25-26, 1986. [DIVISIONAL REPORT MRL 87-19]

Bigu, J. "The effect of time-dependent ventilation and radon (thoron) gas emanation rates in U/G uranium mines"; presented to 3rd Mine Ventilation Symp., Penn. State University, Oct. 12-14, 1987. [DIVISIONAL REPORT MRL 87-78]

Bigu, J. "Progress during the first half of 1987 in the environment projects of the CANMET Minerals Program"; presented to the Joint Panel on Occupational and Environmental Research for Uranium Production in Canada, Saskatoon, Sask., 23-24 June. 1987. [DIVISIONAL REPORT MRL 87-83]

Bigu, J. "Progress during the second half of 1987 in the environment projects of the CANMET Minerals Program"; presented to the Joint Panel on Occupational and Environmental research for Uranium Production in Canada, Elliot Lake, Ont., Oct. 28-29, 1987.
[DIVISIONAL REPORT MRL 87-134]

Bigu, J. "Control of radiation and dust in underground mines"; presented to CANMET/Industry Seminar, Val d'Or, Quebec, Feb. 24-25, 1988. [DIVISIONAL REPORT MRL 87-172

Billette, N.R., Laflamme, M., Keyes, R.J., and Marcoux, L. "Impact de variables quantitatives sur les accidents en souterrain: Analyse multifactorielle"; présenté au séminaire sur "La sécurité minière: prime au rendement vs accidents", Val d'Or, Québec, 12 mars 1987.
[DIVISIONAL REPORT MRL 87-22]

Billette, N.R., and Chouinard, J.-L. "Recherche sur les liens entre boni et accidents: étude préliminaire"; présenté au séminaire sur "La sécurité minière: prime au rendement vs accidents", Val d'Or, Québec, 12 mars 1987. [DIVISIONAL REPORT MRL 87-23]

Billette, N.R. "CANMET's role in mine equipment development"; presented at the Canadian Engineering Centennial Convention, Montréal, Québec, May 22, 1987. [DIVISIONAL REPORT MRL 87-32]

Billette, N.R. "Equipment development trends: CANMET's past and present involvement"; presented at the Canadian Institute of Mining and Metallurgy, Annual General Meeting, Toronto, Ont., May 5, 1987.
[DIVISIONAL REPORT MRL 87-40]

Billette, N.R. "Continuing education needs survey results"; presented at the Canadian Institute of Mining and Metallurgy, Annual General Meeting, Toronto, Ontario, May 5, 1987.
[DIVISIONAL REPORT MRL 87-44]

Billette, N.R. and Laflamme, M. "Influence of various parameters on underground accidents in Québec mines: A multifactorial approach"; presented at the Mine Accident Prevention Association of Ontario 56th Annual Technical Sessions, Toronto, Ontario, May 29, 1987.
[DIVISIONAL REPORT MRL 87-63]

Billette, N. et Tervo, R. "Systèmes d'information et de communication dans les mines souterraines canadiennes"; présenté à Val d'Or, Québec, 24 février, 1988. [DIVISIONAL REPORT MRL 87-143

Bossert, J.A. "Certification des matériels résistant au feu utilisés dans les mines souterraines"; présenté à Val d'Or, Québec, février 24-25, 1988.
[DIVISIONAL REPORT MRL 87-191F]

Bossert, J.A. "Certification of fire-resistant materials for use in underground mines"; presented at the Val d'Or seminar, Val d'Or, Québec, February 24-25, 1988. [DIVISIONAL REPORT MRL 87-191E]

Bossert, J. "Process control in hazardous locations"; presented to a seminar sponsored by the Instrument Society of America, Winnipeg, Manitoba, March 12, 1987. [DIVISIONAL REPORT MRL 87-28]

Boyle, R., Boyer, A., Vongpaisal, S. et Lacourse, P. "Logiciels pour les mines souterraines"; présenté à Val d'Or, Québec, février 24-25, 1988 [DIVISIONAL REPORT MRL 87-146]

Boyer, A., Billette, N.R. and Boyle, R. "Orebodies and mine planning 3-D modelling, Phase I: Geological contours and ore reserves"; presented at the 'First Canadian Conference on Computer Applications in the Mineral Industries (CAMI)', Québec, Québec, March 7-9, 1988
[DIVISIONAL REPORT MRL 87-126]

Boyer, A., et Lacourse, P. "Tour d'horizon des activités des laboratoires de recherche minière" (narration du film vidéo); présenté au séminaire du CANMET, Val d'Or, Québec, 24-25 février, 1988. [DIVISIONAL REPORT MRL 87-145 F]

Dainty, E.D. and Enga, B.E. "Status of Canadian in-mine diesel particulate filter field trials"; presented to the 4th International Mine Ventilation Congress, Brisbane, Australia, July, 1988. [DIVISIONAL REPORT MRL 87-125]

Dainty, E.D. "Improvement of diesel engine performance from the standpoint of gas and soot emissions reduction"; presented at the Val d'Or seminar, Val d'Or, Québec, February 24-25, 1988.
[DIVISIONAL REPORT MRL 87-133 E]

Dainty, E.D. "Amélioration du rendement des moteurs diesel du point de vue des émissions de gaz et de suie"; présenté à Val d'Or, Québec, février 24-25, 1988. [DIVISIONAL REPORT MRL 87-133]

Dave, N. and Lim, T. "Effects of various tailings covers on radon gas emanation from pyritic uranium tailings"; presented to National Symp. on Mining, Hydrology, Sedimetology and Reclamation, Springfield Illinois, December 1987.
[DIVISIONAL REPORT MRL 87-84]

Gangal, M.K. and Dainty, E.D. "Mine environment monitoring system and sensor performance evaluations"; presented at the 3rd mine ventilation symposium, Pennsylvania State University, University Park, Pennsylvania, U.S.A., October 12-14, 1987.
[DIVISIONAL REPORT MRL 87-86]

Gilby, J.L., Yuen, C.M.K., Aston, T.R.C. and Bétournay, M.C. "Suivi géotechnique du fonçage par tunnelier à la mine Donkin-Morien, en Nouvelle-Écosse"; copie de la présentation orale du programme de séminars universitaires canadien sur l'utilisation du tunnelier à la mine Donkin-Morien, du 20 février au 25 mars, 1987.
[DIVISIONAL REPORT MRL 87-70]

Grenier, M. "Wet dust collectors as a means of mineral dust control"; presented to Algoma Branch CIM Meeting, Elliot Lake, Ontario, Jan. 19, 1987. [DIVISIONAL REPORT MRL 87-16]

Grenier, M., Hardcastle, S. and Bigu, J. "Evaluation of a water type dust collector at an underground crushing operation"; presented to 56th Annual Meeting MAPAO, Toronto, Ontario, May 27-29, 1987; and to American Industrial Hygiene Conf., Montreal, Quebec, May 31-June 5, 1987. [DIVISIONAL REPORT MRL 87-51]

Grenier, M. and Bigu, J. "Évaluation des sources et des niveaux de poussière et taux de radiation dans les mines. Stratégies de contrôle"; presented to CANMET/Industry Seminar, Val d'Or, Quebec, 24-25 Feb. 1988. [DIVISIONAL REPORT MRL 87-182]

Hardcastle, S. and Sheikh, A. "Applying tracer gas techniques to evaluate the air distribution in flood leaching stopes"; presented to 89th Annual General Meeting of CIM, Toronto, Ontario, May 3-7, 1987. [DIVISIONAL REPORT MRL 87-41]

Hardcastle, S. and Sheikh, A. "Evaluation of the air quality and distribution during the rest period of bacterial flood leaching operations in uranium mines"; presented to 3rd Mine Ventilation Symp., Penn. State University, Oct. 12-14, 1987.
[DIVISIONAL REPORT MRL 87-75]

Hardcastle, S. and Cavan, J. "A portable computer multi-size, aerosol counting system for use in underground mining environments"; presented to American Industrial Hygiene Conf., Montreal, Quebec, May 31-June 5, 1987. [DIVISIONAL REPORT MRL 87-167]

Hedley, D.G.F. and Udd, J. "The Canada-Ontario-Industry rockburst project"; presented to CIM/ISRM Workshop on Mining Induced Seismicity, Montreal, Quebec, Aug. 30, 1987.
[DIVISIONAL REPORT MRL 87-66]

Hedley, D.G.F. and Rochon, P. "Coups de toit"; presented to CANMET/Industry Seminar, Val d'Or, Quebec, Feb. 24-25, 1988.
[DIVISIONAL REPORT MRL 87-160 F]

Hedley, D.G.F. "Rockbursts"; presented to CANMET/Industry Seminar, Val d'Or, Quebec, Feb. 24-25, 1988.
[DIVISIONAL REPORT MRL 87-160 E]

Hedley, D.G.F. and Rochon, P. "Méthodes d'exploitation souterraines, planification et contrôle des terrains"; presented to CANMET/Industry Seminar, Val d'Or, Quebec, Feb. 24-25, 1988. [DIVISIONAL REPORT MRL 87-165 F]

Hedley, D.G.F. "Underground mining methods, planning and ground control"; presented to CANMET/Industry Seminar, Val d'Or, Quebec, Feb. 24-25, 1988. [DIVISIONAL REPORT MRL 87-165 E]

Herget, G. et Bétournay, M.C. "L'instrumentation dédiée au contrôle des terrains"; présenté à Val d'Or, Québec, février 24-25, 1988. [DIVISIONAL REPORT MRL 87-154]

Jones, D.E.G. and Triebe, R. "Fundamental information for tiger code calculations (2) determination of potential energy function parameters"; presented (in part) at the American Chemical Society 1987 Fall meeting, New Orleans, Louisiana, U.S.A., August 30 to September 4, 1987. [DIVISIONAL REPORT MRL 87-130]

Lee, P.P., Back, M.H. "A study into the thermal decomposition kinetics of nitroguanidine using accelerating rate calorimetry"; presented at the 42nd annual calorimetry conference July 26-31, 1987 at Boulder, Colorado, U.S.A. [DIVISIONAL REPORT MRL 87-77]

Mintz, K.J. "Testing of fire-resistance of materials used in Canadian mines"; presented at the National Research Institute for Pollution and Resources, Tsukuba, Japan, Feb. 17, 1987. [DIVISIONAL REPORT MRL 87-26]

Mogan, J.P., and Dainty, E.D. "Tests of a prototype Venturi scrubber system"; presented to the XXII International Conference of Safety in Mines Research Institutes, Ministry of Coal Industry, 21 Heping Beijie Beijing, China, November 2-6, 1987. [DIVISIONAL REPORT MRL 87-18]

Mogan, J.P., Dainty, E.D., Westaway, K.C., and Horton, A.J. "Mutagen levels in the treated and untreated exhaust of diesel engines in common use in underground mining"; presented to the Annual Meeting of the Environmental Mutagen Society, Charleston, South Carolina, March 27-31, 1988. [DIVISIONAL REPORT MRL 87-181]

Niewiadomski, J. "Source location techniques for seismic activity in mines"; presented to CIM/ISRM Workshop on Mining Induced Seismicity, Montreal, Quebec, Aug. 30, 1987. [DIVISIONAL REPORT MRL 87-69]

Pathak, J. "Canadian Mine Technology Laboratory"; presented at the Canadian Engineering Centennial, Montreal, Québec, May 19-22, 1987. [DIVISIONAL REPORT MRL 87-46]

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[DIVISIONAL REPORT MRL 87-114]

APPENDIX B

Contracts and Research Agreements

Contract Title Status	Contractor	Scientific Authority	Status
Development of Improved Quantity-Distance Storage Requirements for Propellants	Mining Resource Engineering	R.R. Vandebeek	In Progress
Theoretical Model for Predicting Low Velocity Impact Sensitivity Bubble Sensitized Slurry Explosion	Mining Resource Engineering	K.K. Feng	Complete
To Carry Out Field & Laboratory Testing, Field Measurements & Numerical Modelling of Excavations in Potash	Cominco Limited	G. Herget	In Progress
Estimated Reproduction & Operating Costs of Mining Small Mineral Deposits by U/G Methods (UP-R-237)	J.S. Redpath	R.W.D. Clarke	Complete
Design & Development of a Blasthole Depth Measurement Test Set	Davis Engineering Limited	J. Pathak	Complete
Utilization of CO2 as an Engineering Control Parameter for Automated Mine Ventilation (UP-N6-018)	Noranda Mines Limited	M. Gangal	In Progress
Influence of Diverse Variables, including the Bonus Factor, Upon Underground Minine Reproductivity in Québec (UP-A7-007) (Cost Share)	L'Association des Mines & Matériaux du Québec	N. Billette	In Progress
New Brunswick MDA - Use of Backfill in New Brunswick Potash Mines	Denison Potacan Potash Company	G. Herget	Complete

Contract Title Status	Contractor	Scientific Authority	Status
Identification of Input Parameters for Numerical Modelling of Potash Strata at IMC (UP-I-192)	Int. Mineral & Chemical Corporation	G. Herget	In Progress
Regional Subsidence Related to Potash Mining	Central Canada Potash	S. Vongpaisal	In Progress
Research on Microseismic Technology (Saskatchewan MDA)	Potash Corp. of Saskatchewan	D. Hedley	In Progress
Evaluation of Improved Methods for Non-Destructive Testing of Mine-Shaft Wire-Ropes New Brunswick NDA	To Tender	L.B. Geller	In Progress
Salt Anomaly Prediction: Phase I - To Obtain Improved Understanding of Salt Anomalies in Potash Mines to Develop Capacity Occurrence	University of Saskatchewan	S. Vongpaisal	In Progress
New Brunswick MDA - Backfill Mining Trial	Denison Potacan Potash Company	G. Herget	In Progress
Sampling, Fielding and Modelling of a Surface Crown Pillar, Les Mines Selbaie, Québec	C. Mirza Engineering	M. Betournay	In Progress
Development of State-of-the-Art Microseismic Monitoring System (UP-N-204)	Noranda Research Centre	D. Hedley	In Progress
Manitoba MDA, Task 2: Ground Stability Evaluation with Reference to Echelon Lensed Orebody	Sherritt Gordon Mines	S. Vongpaisal	In Progress
Manitoba MDA Task 3: Communication System for Isolated Areas in Mines	Sherritt Gordon Mines	S. Vongpaisal	In Progress

Contract Title Status	Contractor	Scientific Authority	Status
Manitoba MDA, Task 4: Geomechanical Data Base for Ground Control in Deep Mines	Sherritt Gordon Mines	Y.S. Yu	In Progress
Manitoba MDA, Task 1: Develop Vertical Block Method Design Guidelines for Steeply Dipping Orebody Techniques	INCO Limited	J. Pathak	In Progress
Manitoba MDA, Part III Task 5: Optimization of Blast Design for Blasthole Mining Operators	INCO Limited	J. Pathak	In Progress
Manitoba MDA, Task 6: Delayed Backfill Consolidation	Hudson Bay & Smelting	A. Annor	In Progress
(F.E.) Modified Personal Alpha Dosimeter	Atomic Energy Control Board	J. Bigu	Complete
The Influence of Turbulence on Dust-Air Explosions	McGill University	E.D. Dainty	In Progress
Synthesis of Current Knowledge of Sulphide Ore Dust Explosition Phenomena	University of Sydney	E.D. Dainty	In Progress
Continuous Analysis of Gases and Dust Before, During and After Blasting in Canadian Sulphide Ore Deposits	Noranda Research Centre	E.D. Dainty	In Progress
Addendum to 'Health Implications of Exposure of Underground Mine Workers to Diesel Exhaust Emissions - Update'	Ian W. French & Association	J.P. Mogan	In Progress
Determination of Levels of Dinitropyrenes on Diesel Particulate Exhibiting Excess Mutagenic Activity	Laurentian University	E.D. Dainty	In Progress

Contract Title Status	Contractor	Scientific Authority	Status
Hydrogeochemical Investigation of Reactive Sulphide Tailings at the Waite Amulet Trailings Site, Noranda, Québec - Phase II	Noranda Incorporated	N. Dave	In Progress
Hydrochemical Investigations of Reactive Sulphide Tailings at the Waite Amulet Tailings Site, Noranda, Québec - Phase 3 (53/47 Cost Shared)	Noranda Incorporated	N. Dave	In Progress
In-Situ Determination of Dewatered Tailings Fill Properties in Ontario Mines - Ontario Mineral Development Agreement	Dome Mines Limited	A. Annor	In Progress
In-Situ Determination of Dewatered Tailings Fill Properties in Ontario Mines - Ontario Mineral Development Agreement	INCO Limited	A. Annor	In Progress
In-Situ Monitoring and Computer Modelling of A Cemented Sill Mat - Ontario Mineral Development Agreement	Falconbridge Limited	A. Annor	In Progress
The Use of Consolidated Fills for Controlling Violent Pillar Failure in Ontario Mines - Ontario Mineral Development Agreement	Denison Mines Limited	D. Hedley	In Progress
In-Situ Properties of Backfill Alternatives in Ontario Mines - Ontario Mineral Developmet Agreement	Falconbridge	A. Annor	In Progress
Simulation of Bulk Mining at Depth with Backfill in Ontario Mines - Ontario Mineral Development Agreement	INCO Limited	Y. Yu	In Progress

Contract Title Status	Contractor	Scientific Authority	Status
Liquefaction Potential of Dense Backfill in Ontario Mines - Task 7 (Can/Ont MDA Part III)	Domes Mines	A. Annor	In Progress

APPENDIX C

REPRESENTATION ON TECHNICAL COMMITTEES

INTERNATIONAL

CANADIAN SUBCOMMITTEE OF THE INTERNATIONAL ELECTROTECHNICAL COMMISSION, TECHNICAL COMMITTEE 31

Electrical Apparatus for Explosive Atmospheres (chairman)................................... J.A. Bossert
Subcommittee 31G (member)...................... G. Lobay
Subcommittee 31H (member)...................... K.J. Mintz

INTERNATIONAL ELECTROTECHNICAL COMMISSION SUBCOMMITTEE 31A

Flameproof Enclosures (chairman) .... J.A. Bossert

INTERNATIONAL SOCIETY FOR ROCK MECHANICS (ISRM)

Council (Canadian Member)......................... J.E. Udd

Commission on Case Histories...................... D.G.F. Hedley

Committee on 1987 ISRM Congress, Montreal (General Chairman)............................... G. Herget

INTERNATIONAL STANDARDS ORGANIZATION CANADIAN ADVISORY COMMITTEE

Committee on Certification - CAOCO (member)....... J.A. Bossert
Technical Committee 41/Subcommittee 3, Conveyor belting (member).................................. K.J. Mintz
Technical Committee 146 - Air Quality and Working Groups SiO_2 and Inorganic Fibres (member)... G. Knight

INTERNATIONAL TUNNELLING ASSOCIATION

Tunnelling Association of Canada (member)......... J.E. Udd

ORGANIZATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

International Group of Experts on Unstable Substances (IGUS) (national representative)....... R.R. Vandebeek

IGUS - Ammonium Nitrate Working Group (co-leader).... R.R. Vandebeek

NEA International Intercalibration and intercomparison Program for Radon, Thoron and their Daughters (member).............................. J. Bigu

UNITED NATIONS

Group of Experts on Explosives (delegate).......... R.R. Vandebeek

UNITED STATES OF AMERICA

INSTRUMENT SOCIETY OF AMERICA

Committee SP 12 Instruments for Use in Hazardous
Locations (member)................................ J.A. Bossert

COLLABORATIVE PLANNING COMMITTEE FOR DIESEL EMISSION REDUCTION R & D

(CANMET representative)........................... E.D. Dainty

CANADA - FEDERAL

CANADIAN GOVERNMENT SPECIFICATIONS BOARD (CGSB)

Diesel Fuel panel of the CGSB Subcommittee on
Middle Distillates (member)....................... J.P. Mogan

ENERGY, MINES AND RESOURCES CANADA (EMR)

Canada-Ontario-Industry Rockburst Project
Project Management Committee (member)............. J.E. Udd
Project Technical Committee (chairperson)......... D.G.F. Hedley

Committee on Radioactive Waste Containment
(member).. G.E. Larocque

Long-term Management of Reactive Acid Tailings
Sulphides Steering Committee - (member)........... J.E. Udd
Technical Working Group - (member)................ R. Tervo

Occupational and Environmental Research for
Uranium Production, Joint Panel (secretary)....... R. Tervo
(member).......... J. Bigu

Uranium Resource Appraisal Group:
Subcommittee on Reasonably Assured
Resources of Uranium (chairman)................... A. Füstös

Uranium Resource Appraisal Group:
Subcommittee on Estimated Additional
Resources of Uranium (member)..................... A. Füstös

Uranium Resource Appraisal Group:
Subcommittee on Economics of Supply
and Demand for Uranium (member)................... A. Füstös

Uranium Resource Appraisal Group (member)............. A. Füstös

TRANSPORT CANADA

Technical Committee on Dangerous Goods (member)....... R.R. Vandebeek

CANADA - OTHER

CANADIAN GAS ASSOCIATION

Gas Fired Appliances for Hazardous Locations,
No. CGA 2.25 (member)................................ G. Lobay

CANADIAN GEOTECHNICAL SOCIETY

Ottawa Geotechnical Group (executive member).......... M. Bétournay

Subcommittee on Tunnelling (member)................... M. Gyenge

CANADIAN GEOTECHNICAL SOCIETY

Ottawa Geotechnical Group (executive member).......... M. Bétournay

Subcommittee on Tunnelling (member)................... M. Gyenge

CANADIAN INSTITUTE OF MINING AND METALLURGY (CIM)

Ad-Hoc Committee on Mining and Mineral Processing
Research (member).................................... J.E. Udd
(member)... N. Billette

Algoma Branch (laboratory representative)............. B. Arjang

Ottawa Branch (executive committee member)............ D. Walsh

Committee on Education for the Mineral Industry
(vice-chairman)...................................... N. Billette
(member)... J.E. Udd

Rock Mechanics and Strata Control Committee
(chairman)... J.E. Udd

Subcommittee on Non-Explosive Breakage Methods
(member)... M. Gyenge

Subcommittee on Monitoring (member)................... G. Herget

Subcommittee on Soft Rock (member).................... G. Herget

CANADIAN ROCK MECHANICS ASSOCIATION - CARMA

(chairman)... J.E. Udd

CANADIAN STANDARDS ASSOCIATION

Standards Steering Committee on Electrical and Mechanical Mines Safety (vice-chairman)............ J.A. Bossert

Technical Committee for "Flameproof Diesel-Powered Vehicles for Use in Gassy Underground Mines" M424 (chairman).................................. E.D. Dainty

Technical Committee on Accoustics and Noise Control (Construction & Mining Machines - Task Force on Occupational Noise) (member)............. M. Savich

Technical Committee on Fire Resistant Conveyor Belting, No. M4.22 (member).............................. K.J. Mintz

Technical Committee on Fire Resistant hydraulic Fluids, No. M4.23 (member).............................. K.J. Mintz

CANADIAN STANDARDS ASSOCIATION
CANADIAN ELECTRICAL CODE, PART I

Steering Committee (member)............................. J.A. Bossert

Subcommittee on Section 18 (Chairman)................... J.A. Bossert

CANADIAN ELECTRICAL CODE, PART II

Subcommittee on CSA Standard C22.2, No. 30: Explosion Proof Enclosures for Use in Class I, Groups, A,B,C and D Hazardous Locations (member)....... J.A. Bossert

Subcommittee on CSA Standard C22.2, No. 137: Luminars for Hazardous Locations (member).............. G. Lobay

Subcommittee on CSA Standard C22.2, No. 152: Combustible Gas Detection Equipment (member)........... G. Lobay

Subcommittee on CSA Standard C22.2, No. 157: Intrinsically Safe and Non-Incendive Equipment for Use in Hazardous Locations (vice-chairman)............ G. Lobay

Subcommittee on CSA Standard C22.2, No. 159: Plugs and Receptacles for Hazardous Locations (member).. G. Lobay

Subcommittee on CSA Standard C22.2, No. 174: Cables to Used in Hazardous Locations (member)......... G. Lobay

CANADIAN ELECTRICAL CODE, PART V

Committee on CSA Standard C22.5 Use of Electricity in Mines (member)................... G. Lobay

CANADIAN URANIUM PRODUCERS METALLURGICAL COMMITTEE

(member)... N..K. Davé
(member)... T.P. Lim

SAULT COLLEGE, ELLIOT LAKE

Advisory Committee for the Ventilation
Technician Option of the Mechanical
Technology Course (member)............................ S. Hardcastle
(member)............................ R. Tervo

CAMBRIAN COLLEGE, SUDBURY

Advisory Council for Mining Ciriculum (member)......... C.B. Graham

INOTITAT DE RECHERCHE EN SANTE ET SECURITE DU TRAVAIL

Comité des sciences naturelles et génie................ N. Billette

APPENDIX D

CONTACTS, MEETINGS, FIELD TRIPS AND JOINT CONSULTATIONS

INDUSTRY

Algoma Steel
Armstrong Monitoring Corporation
Atlantic Nuclear Limited
Atlantic Nuclear Services
Bapty Research, Kimberley, British Columbia
Beaver Construction Group
Bill Cox, Tunnelling Consultant
Blackbox Controls Limited
Bombardier Incorporated
Canada Wire and Cable Limited
Canadian Autoworkers Association
Canadian Press
Canadian Refractories Limited
CBC Radio & TV, Sudbury, Ontario
CBJN Products
Champion Spark Plug
C-I-L Incorporated
CIS-CAN Sales Limited
C. Ito and Company
Conspec
Corporation des Maîtres Électriciens du Québec
Crothers (Caterpillar)
Crouse-Hinds Limited
Curragh Resources
David R. Hughson Limited
Denison Mines Limited
Detour Lake Mines
Dupont Canada Incorporated
Elliot Lake Standards
Elliot Rubber and Plastic
Engine Control Systems (ECS) Limited
Ensign-Bickford
Falconbridge Limited
Fantalum Mining Corporation
Flotech Distributors
G.E.C. Diesels, Toronto
Geodemiter of Canada Limited
Golder Associates
Goodyear Canada
Goodyear Fire and Rubber
Hands Fireworks Incorporated
Honda Motor Company/Canada
Hudson Bay Mining and Smelting
INCO Metals
Industrial Development and Manufacturing Incorporated
Instantel Limited
J.S. Redpath Limited
Kidd Creek Mines Limited
Kubota Tractor Canada Limited
Laventhan & Howrath Managements Consultants

Industry (cont'd)

Liquid Air Engineering Corporation
Lovat Tunneling Equipment
Lynx Systems, Vancouver, British Columbia
Med-Eng Systems Incorporated
Noranda Research, Pointe Claire, Quebec
Novacore Chemicals
Pass & Seymour Company
Polaris Mine, Northwest Territories
Proctor and Redfern Limited
Pyroban Limited
Resource Technology Centre
Rio Algon Limited
Roy Ball Associates
Ruttan Mine
Saskatchewan Potash Corporation
Sherritt-Gordon Mines Limited
Sypher-Mueller International
Tech Corporation, Vancouver, British Columbia
Technical Company, Montreal, Quebec
Thomas and Betts Limited
Townend, Stegura, Baleshta and Nichols
Tridex Systems
TV Ontario "The Science Magazine"
United Keno Hill Mine
United Steelworkers Association
Viscase Canada
Vycan Building Products
Westech Industrial Limited
Wood-Banani Consultants
WPL Technology, Toronto

INTERNATIONAL

Austrian Trade Division
Billiton Research Centre, The Netherlands
Calweld Incorporated, U.S.A.
Clarklift Newcastle, Australia
Department of Environment, U.S.A.
Department of Mines, Botswana, Africa
Dupont Company, U.S.A.
Elbevier Science Publishers, Amsterdam
Ferrous Corporation, U.S.A.
Fosroc Technology, Birmingham, England
Frank & Huster AG, West Germany
Galena Mine; U.S.A.
General Monitors Incorporated, U.S.A.
Georgia Duck, U.S.A.
Getman Corporation, Bangor, U.S.A.
Gimelec, Paris, France
Hawke Cable Glands Limited, England

Hemscheidt America Corporation, U.S.A.
Hilton Rubbers Limited, New Delhi, India
Hindustan Zinc Limited, Udaipur, India
Honda Motor Company, Japan
Institute of Technology, Oso, Japan
Institution of Electrical Engineers, London, England
ITT Barton Fluid Technology Corporation, U.S.A.
Kerr-McGee Coal Company, U.S.A.
L'Assemblea Legislative, Costa Rica
Mayreder Limited, Austria
Ministry of Economic Affairs, The Netherlands
Ministry of Mines, Costa Rica
Multiprobe Incorporated, U.S.A.
Norwegian Institute of Technology
Rohm & Hans, U.S.A.
Romanian Enterprise of Rare Metals, Bucharest, Romania
Underwriter's Laboratories Incorporated, U.S.A.
United Kingdom Ministry of Defence
United States Bureau of Mines
United States Department of Energy
Uranium Institute of China
Volvo BMAB Sweden

FEDERAL

Atomic Energy of Canada Limited
Canadian Centre for Occupational Health & Safety
Canadian Embassy, Prague, Czechoslovakia
Canadian Standards Association
Department of National Defence
Dominion Fire Commissioner's Office
Herzberg Institute of Astrophysics (NRC)
Labour Canada
National Research Laboratory
Royal Canadian Mounted Police
Transport Canada

PROVINCIAL

Alberta Research Council
British Columbia Ministry of Energy, Petroleum & Natural Resources
Energy, Mines and Petroleum Resources, British Columbia
Kingston General Hospital
Manitoba Department of Energy and Mines
Mine Accident Prevention Association of Manitoba
Mine Accident Prevention Association of Ontario
Mining Association of Manitoba
Ministry of Labour
Ministry of Northern Development and Mines

New Brunswick Occupational Health & Safety Commission
New Brunswick Mine Inspectorate
Newfoundland Department of Labour
Northwest Territories Chamber of Mines
O.C. Transpo
Ontario Mining Association
Ontario Ministry of Industry, Trade & Technology
Ontario Research Foundation
Ontario Workmen's Occupational Safety and Health Centre
Province of Saskatchewan
Quebec Ministry of Mines and Native Affairs
Research Productivity Council of New Brunswick
Saskatchewan Department of Labour
Saskatchewan Mining Association
Saskatchewan Potash Producers Association

UNIVERSITIES

Cambrian College
CKUT-FM Radio McGill
Colorado School of Mines
Haileybury School of Mines
Helsinki University of Technology
Laurentian University
Laval University
Royal School of Mines, England
University of Alberta
University of Manitoba
University of Sydney
University of Toronto
Zacatecas University, Mexico

TRAVEL AND COSTS FOR 1987-88

Regular A-Base Funds

1. Conferences Attended: 19
   Total Cost: $23,954.47

2. Seminars/Meetings Attended: 75
   Total Cost: $85,112.27

3. Site Inspections/Mne Visits Attended: 120
   Total Cost: $47,711.92

4. Training/Education Taken: 24
   Total Cost: $27,185.82

Canada/Ontario Mineral Development Agreement

1. Seminars/Meetings Attended: 119
   Total Cost: $13,506.78

2. Site Inspections/Mine Visits Attended: 1
   Total Cost: $273.70

Canada/Manitoba Mineral Development Agreement

1. Seminar/Meetings Attended: 10

2. Total Cost: $9,138.32

Canada/New Brunswick Mineral Development Agreement

1. Seminar/Meetings Attended: 5
   Total Cost: $2,971.18

2. Site Inspections/Mine Visits Attended: 2
   Total Cost: $1,074.25

APPENDIX E

COST RECOVERY

Company	**Number of Samples/Tests**	**Amount Invoiced**
Anecan Industries Inc.	1	$ 337.00
Appleton Electric Ltd.	16	3,459.00
Atomic Energy of Canada Ltd.	246	24,569.15
Beaver Construction Group Ltd.	2	3,941.10
Bestobell Canada Ltd.	1	184.50
Birelli Cables Ltd.	3	858.50
Canadian Gas Association	3	827.00
Canadian Standards Association	165	32,370.50
Cis-Can Sales	2	551.00
Crother Ltd.	37	4,695.00
Crouse-Hinds Elect. Construction Materials	10	1,592.00
Detector Electronics Corp. (U.S.A.)	8	2,173.00
Demysh Heating Equip. Co.	4	1,103.00
J.M. Fenner & Co. Ltd. (U.K.)	41	13,504.50
Georgia Deck & Cordage Mill (U.S.A.)	14	3,647.00
Goodyear Tire & Rubber Co.	3.5	1,711.50
Hausherr - D&P Ltd. (U.K.)	2	369.00
Hands Fireworks Inc.	109	2,725.00
Hemscheidt American Corp. (U.S.A.)	2	369.00
E.F. Houghton Canada Ltd.	3	597.50
Liquid Transfer Systems Ltd.	3	398.00
MSA Canada Inc.	2	369.00
NEI Mining Equip. Canada	1	184.50
OC Transpo	4	4,059.00
Phillips Cables Ltd.	5	921.00
Polymer International (N.S.) Ltd.	7	796.00
Professional Products of Canada Inc.	4	705.00
Roven Mining Equip. Company	1	184.50
Schauenbury Industries Ltd.	5	797.00
Scandura Mining Products Co. (U.K.)	26	8,281.00
Shawflex Inc.	1	275.50
Simark Controls Ltd.	1	184.50
Stafford Textiles Ltd.	2	368.00
Status Engineering Inc. (U.K.)	3	553.50
Tom Roy Fiberglass Mfg. Ltd.	1	184.00
Trans-Canada Electro Ltd.	4	889.00
Westech Industrial Ltd.	5	1,377.50
Westfalia Lanen (West Germany)	2	396.00
Sub-Total	**749.5**	**$120,507.25**

Cost Recovery (cont'd) - X-Ray Analysis Elliot Lake Laboratory

Company	Number of Samples/Tests	Amount Invoiced
Giant Yellownite Mines Ltd.	32	$ 544.00
Govt. of Newfoundland & Labrador	12	204.00
Hemlo Gold Mines Ltd.	58	986.00
Canada Indian & Northern Affairs	3	51.00
Health & Welfare Canada	2	34.00
Noranda Mines Ltd.	53	901.00
Ontario Hydro	67	1,139.00
Renabie Mines (1981) Ltd.	6	102.00
Sherritt Gordon Mines Ltd.	9	153.00
Sub-Total	**242**	**$ 4,318.00**

Recovered Travel Expenditures

Beaver Construction	Travel	$ 2,440.50
Brunswick Mining and Smelting Corp.	Travel	2,127.88
Canadian Standards Association	Travel	540.75
C.I.M.	Travel	3,874.10
Hausherr - D&P Ltd. (U.K.)	Travel	575.35
McPherson, Leslie, Tyerman (Barristers)	Travel	4,953.16
Newfoundland Department of Labour	Travel	627.53
Staats, Howard E. Q.C.	Travel	254.98
Standards Council of Canada	Travel	1,847.56
Total	**11 Trips**	**$17,241.81**

Other Miscellaneous Cost Recovery

R.C.M.P. to construct Safety Shelter	1,660.90
Atomic Energy Control Board - Supplies and Courier charges	340.96
	2,001.86

Total Number of Billings	134	
Total Number of Companies	56	
Total Number of Tests/Samples	971.5	124,825.25
Total Number of Trips/Travel	11	17,241.81
Other Misc. Items	2	2,001.86
Total		**$144,068.92**

APPENDIX F

PROFESSIONAL, TECHNICAL AND ADMINISTRATIVE STAFF AND STAFF CHANGES

PROFESSIONAL, TECHNICAL AND ADMINISTRATIVE STAFF

NAME	DEGREES AND DIPLOMAS	OCCUPATIONAL CATEGORY
HEADQUARTERS		
J.E. Udd	B.Eng., M.Eng., Ph.D. (McGill); P.Eng	Director
J.S. Davidson		Secretary
ADMINISTRATION		
E.C. Tupper		Admin. Officer
M. Hamel		Publications
D.M. Hill		Spec. Proj. Officer
S.C. Pollock		Word Processor
C. Sleeth		Finance & Travel
CANADIAN EXPLOSIVE ATMOSPHERES LABORATORY		
J.A. Bossert	B.Sc. (Queen's), P.Eng.	Manager
M.I. Inglis		Secretary
M.J. Boyle	Dipl. (Mech. Tech.) (Algonquin)	Technologist
K.C. Cheng	B.Sc., M.Eng., (Tainan Chen-Kung, Taiwan)	Engineer
E.D. Dainty	B.Sc., M.Sc., (Toronto) P.Eng	Res. Sci.
D.D. Dainty	Dipl. (Inst. Tech.) (Algonquin)	Technologist
J.A.D. Ebersole	Dipl. (Elect. Tech.) (Ryerson)	Technologist
L. Geller	Dipl. Ing. (Mech. Eng.) (Budapest), B.Sc. (Eng.) (London), M.A.Sc. Toronto)	Res. Sci.
K. Judge	B.Sc., (Geology) (Carleton) (Electronics) (Algonquin)	Technologist
G. Lobay	B.Sc. (Manitoba), P.Eng.	Engineer
K.J. Mintz	B.Sc., M.Sc. (UBC); PhD. (Toronto)	Res. Sci.
J.P. Mogan	B.S.Sc. (Toronto), P.Eng.	Res. Sci.
M.J. Ralph	Dipl. (Elect. Tech.) (Algonquin)	Technologist
N.K. Sarin	P. Eng. B.A.Sc. (Hons) Mech Eng Waterloo	Engineer
J.A. Vallieries	Dipl. (Mech. Tech.) (St. Michael's)	Technologist
CANADIAN EXPLOSIVES RESEARCH LABORATORIES		
R.R. Vandebeek	B.Sc., M.Sc. (Carleton)	Manager
J. Campbell		Clerk
R. Augsten	Dipl. (Agri. Tech.) (Jena, Germany)	Technologist
E. Contestabile	B.Sc. (Carleton)	Phys. Sci.

D. Cox	Dipl. (Drilling & Blasting) (Sir Stanford Flemming)	Technologist
T. Craig	Dipl. (Biochem. Tech.) (Algonquin)	Technologist
K.K. Feng	B.Sc., P.Eng., M.Sc., Ph.D. (Iowa)	Res. Sci.
D.E.G. Jones	B.Sc., Ph.D. (Western)	Res. Sci.
P. Lee	B.Sc. (Hong Kong Baptist)	Chemist
E. Nagy	Dipl. (Electr. & Mech. Tech.) (Ryerson)	Technologist
E.T. Pike	Dipl. (Chem. Tech.) (Dawson)	Technologist

ELLIOT LAKE LABORATORY

R.O. Tervo	B.A.Sc. (Toronto), Ph.D. (Bradford);P.Eng.	Manager
F. Lelièvre		Secretary
E. McElrea		Office Manager
J. Nipius		Financial Clerk
A.M. Webster		Rpts. & Publ'ns
B. Arjang	B.Sc., M.Sx., Ph.D. (Germany)	Res. Sci.
J. Bigu	M.Sc. (Barcelona), DTC (BA++) (Slurry) PH.D. (Queen's)	Res. Sci.
Y.M. Boucher	Dipl. (Bio Science Tech.) (St. Clair)	Technologist
K.C. Butler	B.Sc. (Laurentian)	Technologist
N.K. Davé	B.Sc., M.Sc. (Rajastan, India), Ph.D. (Queen's)	Res. Sci
A.J. Frattini	Dipl. (Inst. Eng. Tech.) (Ind.)	Technologist
M. Grenier	B.Sc., M.Sc. (Laurentian)	Res. Sci.
S.G. Hardcastle	B.Sc., Ph.D. (Nottingham, England	Res. Sci.
D.G.F. Hedley	B.Sc., Ph.D. (Newcastle), P.Eng.	Res. Sci.
T. Jewiss	Dipl. (Min. Tech.) (Cambrian)	Technologist
T.P Lim	B.Sc. (Ottawa), Dipl. (Radio Chem. Tech.) (Munich, West Germany)	Phys. Sci.
P. Rochon	M.Sc., (Montreal)	Phys. Sci.
W. Ropchan	Technology (Cambrian)	Technologist
J.A. Smith		Technologist
W. Zawadski		Technologist

CANADIAN MINE TECHNOLOGY LABORATORY

G.E. Larocque	B.Sc. (Carleton)	Manager
J.E. Byford		Secretary
C.D. Baxter		Word Processor
A.B. Annor	B.A.Sc. (Ottawa); M.Eng. (Carleton); P.Eng.	Phys. Sci.
M. Bétournay	B.Sc., M.Sc.A., B.Eng. (McGill); P.Eng.	Phys. Sci.
N. Billette	B.A. (Bourget), B.Sc., M.Sc., Ph.D. (École Polytechnique)	Res. Sci.

A. Boyer	B.Sc. (Montreal)	Phys. Sci.
R. Boyle	B.Sc. (Ottawa)	Phys. Sci.
R.W.D. Clarke	B.Eng. (NSTC), P.Eng.	Engineer
J. Folta		Draftsperson
A. Füstös	B.S.F./F.E., B.Sc. (UBC); M.Sc. (Carleton); P.Eng.	Engineer
M. Gangal	B.Sc. (Agra, India); M.Sc. (Rorkee, India & McGill); Ph.D. (Calgary)	Res. Sci
B. Gorski	Dipl. (Eng.) (St. Marks)	Technologist
C.B. Graham	B.Sc., M.Sc. (Eng.), (Queen's)	Phys. Sci.
M. Gyenge	Dipl. (Eng.) (Budapest), P.Eng.	Res. Sci.
G. Herget	B.Sc. (Goettingen, West Germany) M.Sc., Ph.D (Munich, West Germany);	Res. Sci.
F. Kapeller	Dipl. (Ind. Elect.) (Austria)	Technologist
G. Knight	B.Sc. (Birbeck, London)	Res. Sci.
R. Jackson	B.S.Sc. (Waterloo); P.Eng.	Phys. Sci.
J. Pathak	B.Eng., (Min.Eng.) (Sagar, India), Ph.D. (Freiberg, Germany)	Engineer
N.A. Toews	B.Sc. (Queen's)	Res. Sci.
S. Vongpaisal	B.Eng., M.Eng., Ph.D. (McGill); P.Eng.	Res. Sci.
D.F. Walsh	B.Sc. (Memorial)	Phys. Sci.
A.S. Wong	B.Sc. (National Taiwan University) M.Sc. (Ottawa)	Phys. Sci.
Y.S. Yu	B.Sc., M.Eng. (McGill)	Res. Sci.

SECONDMENTS

H. Black - December 1987 to May 1988 - from TID
H. Porter - June 1987 to March 1988 - from Denison Mines
A. Eden - November 1987 to March 1988 - from Laurentian University

STUDENTS

Co-op
- May to August - R. Rouleau, R. Triebe
- September to December - R. Rouleau, J. Morning, R. Triebe, C. Neveau
- January to April - G. Hamel, C. Lee, M. Little, A. Westcott, P. Giroux, W. Kozyra, S. Cotterill, C. Neveau, M. Petersen, J. Williams

Cosep
- May to August - H. Kim, S. Goldberg

Terms:
- N. Davidson
- F. Khan
- M. Plouffe
- M. Mulvihill

STAFF CHANGES

APPOINTMENTS AND PROMOTIONS

N. Sarin	Engineer - CEAL - June 86
D. Cox	Technologist - CERL - July 86
J.S. Davidson	Secretary to Director - July 86
L. Geller	Res.Sci. - CEAL - September 86
D.M. Hill	Special Projects Officer - September 86
K. Judge	Technologist - CEAL - February 87
Tom Bemadeni	- March 1987
R. Jackson	Phys. Sci. - CMTL - March 1987
F. Lelièvre	Secretary - ELL - August 87

SEPARATIONS

L. Tirrul	June 1986
J.P. Mogan	August 1986
C. St.Jean	September 1986
A. Makuch	October 1986
H. Poliquin	October 1986
D. Dugmore	December 1986
M. Ralph	February 1987
M. Savich	February 1987
D. Dinel	April 1987
R.J. Welwood	May 1987
M.J. Boyle	August 1987
G. Vaillancourt	August 1987
S.C. Pollock	January 1988
D. Hanson	January 1988
P. Lacourse	February 1988